SAIL 95

USER'S MANUAL

Serial Number: 000625

Sail 95

User's Manual

VERSION 1

Published by

Vivid Simulations
90 High Street
Clinton, CT 06413-1721
USA

See the README.TXT file included with the software for information about contacting technical support.

Printed In The United States of America

Table Of Contents

Introduction

A Note from the Author

Thank you for purchasing *Sail 95*. I believe you will find it as exciting and challenging to play as it was for me to create. *Sail 95* is many things. For the non-sailor it is an aesthetically breathtaking demonstration of the beauty of computer generated graphics as well as an entertaining and challenging game. For the sports enthusiast it is a finely detailed look at one of the oldest and grandest ongoing competitions of western civilization. For the novice sailor it is a valuable introduction to the excitement of sailing high performance yachts. For the experienced sailor it is a superbly realistic model of yacht performance and wind conditions. For the competitive racer it is a sophisticated tactical simulator with which to practice skills and build new strategies. For the actual tacticians and navigators competing in the 1995 America's Cup it is a chance to rehearse the race under various wind and weather conditions.

Because *Sail 95* pushes the limits of current computer technology, please read the installation chapter carefully. The chapter entitled *Quick Start* will give you a taste of the simulation right away. The experienced sailor can skip the chapters on sailing theory, wind, and racing tactics although he will find valuable insights into the working of the simulator. The novice sailor will find these chapters present a clear introduction to these subjects and his enjoyment of the simulator will be heightened by the knowledge they impart. The chapter *Program Reference* describes all aspects of the simulator and should be read by all after playing the quick race. *Performance Data* contains measured performance statistics for the International America's Cup Class yacht as modeled

in the simulator. Finally, a brief bibliography is provided for those wishing to learn more about sailing and racing.

I must off to the sea again,
To the lonely sea and sky.
And all I ask is a tall ship,
And a star to steer her by.

- Longfellow

Installation

Important

Sail 95 installation is fairly easy. You must, however, follow these instructions. Failure to do so may result in an incorrect installation and will be evidenced by incorrect image colors when you play *Sail 95*. **Read this section carefully**. The section on performance issues contains some advice on how to optimize your system both before and after installation, so read this section before you start installation.

Minimum Requirements

Sail 95 **requires** the following:

- 486DX33 PC or better
- 8 Mb of system RAM
- 20 Mb free hard disk space during program installation
- Video card capable of 1024 x 768 resolution in 256 colors under Windows (at least 1 Mb of VRAM or DRAM)
- Monitor capable of displaying at least 1024 x 768 resolution
- Mouse
- Microsoft Windows 3.1 or higher

If your PC does not meet these requirements, you **cannot** play *Sail 95*.

Recommended Requirements

The following are recommended:

- 486DX66 PC or better
- Local bus video card
- 17" monitor or larger
- Sound card
- Joy-stick
- 32 bit Windows operating system (Windows NT or Windows 95)

Windows 3.1 Installation

The installation procedure for Windows 3.1 is as follows:

Step 1

Start Windows in 386 Enhanced mode.

- Windows 3.1 should start in 386 Enhanced mode when you type "win" at a DOS prompt. This can be checked by looking at the "About ..." item in the help menu of the Program Manager.

- If Windows does not come up in 386 enhanced mode and it is being loaded from a batch file, ensure that there are no command line switches present after the "win" or "win.exe" command.
- Refer to your Windows documentation for further information about Windows modes.

Step 2 **Ensure that Windows has at least 10 Mb of available memory.**

- Look at the "About ..." item in the help menu of the Program Manager to see how much memory is available to Windows. If this number is less than 10,000 Kb, you will need to create a Windows virtual memory swap file as follows:
- Open the Control Panel and then open the 386Enh item. Select the "Virtual Memory" option.
- Create a permanent swap file large enough to give you the necessary 10 Mb of Windows memory.
- If none of your disk drives is listed as being able to create a large enough swap file, yet there is sufficient room on the disk, you need to defragment that drive. Exit Windows and type "defrag" at the DOS prompt. Follow the on-screen instructions and select "full optimization." When the drive is defragmented, re-enter Windows and create the swap file.
- Refer to your Windows documentation for more information about virtual memory and swap files.

Step 3 **Check that the display setting is set to 1024 x 768 x 256 colors.**

- Open the Windows Setup utility and look at "Display Settings." If this is not set to the proper setting, use "Change System Settings" in the Options menu to set up the appropriate driver. Select a 1024 x 768 x 256 color driver with "Large Fonts." If this is not an option, obtain the necessary driver from your video card manufacturer. Most maintain a bulletin board from which you can download their latest Windows drivers.
- Refer to your video card documentation for further information.

Step 4 **Ensure no applications in the "Start Up" group use 256 colors.**

- *Sail 95* achieves some of its speed by preloading all the images for the sailboats during the installation: it then retrieves these as necessary during game play. It's ability to do this depends upon Windows being in the same state as regards color mapping when *Sail 95* is installed and when *Sail 95* is run. As long as everything is the same when the game is installed and when it is run, everything should be OK. It is, however, easiest to just remove any 256 color applications from the "Start Up" group before you install the game, and ensure that no 256 color applications have been running before you play it.
- Possible programs that should be moved out of the "Start Up" group include screen savers and daily desk calendar programs that use detailed graphics.

- If you have Microsoft's *Video for Windows* installed, *Sail 95* will use it for a brief animation whenever the program loads. (*Video for Windows* is included with many CD ROM Windows applications.) If a program installs or you deinstall *Video for Windows* **after** you have installed *Sail 95,* you will have to reinstall *Sail 95*.

Step 5 **Set up sound and music card.**

- Ensure that you have appropriate wave and MIDI audio drivers loaded.
- If your sound card has music capabilities, set up the Windows MIDI Mapper (in the Control Panel) to access it. The MIDI music in *Sail 95* contains both general and extended MIDI information. This means that you need to select **either** a general MIDI setup (channels 11-16 in the MIDI Mapper) **or** an extended MIDI setup (channels 1-10), **not both**. The extended setup is recommended.
- If you have additional sound module or MIDI capabilities, set up your system appropriately. The program assignments in *Sail 95's* MIDI files use Roland General MIDI type instrument assignments (the only standard there is at present, also used by most internal sound modules), i.e. program 1 is an acoustic grand piano, etc. If you have a sound module that does not support this mapping, you will need to set up the patch maps in the MIDI Mapper appropriately.
- Refer to your sound card documentation for further information.

Step 6 **Make a backup copy of the diskettes.**

- *Sail 95* will install everything it needs to run onto your hard drive. To save HDD space you can, however, remove the files used to generate the sailboat images after they are generated. If you need to reinstall *Sail 95* at a later time (and you may: see about *Video for Windows* above), you **must** use the diskettes. Enough said.

Step 7 **Install Sail 95.**

- Start Windows.
- Insert diskette 1 (Setup) into your floppy drive.
- Run "SETUP.EXE" from either the file manager or the program manager. From the file manager, double click on "SETUP.EXE". From the program manager, Select the File ... Run menu item and type in "[drive name]:\SETUP.EXE" then enter where [drive name] refers to the letter designation of your 3.5" floppy drive (either A or B.)
- Follow the on screen instructions to select the drive and directory to which you want *Sail 95* installed.
- After loading the information from the floppy disks, the install program will create the sailboat images. Image creation may take up to 30 minutes, but can be unattended after you have completed the copy protection.

Step 8

Delete the "SHIP" subdirectory (optional).

- You can free up about 6 Mb of disk space after installation by deleting the entire "SHIP" subdirectory. Only delete this subdirectory once you are satisfied that the installation was successful.
- **DO NOT** delete the "SHP" subdirectory. These are the files that were created during the installation from the PCX files in the "SHIP" subdirectory.

Windows NT or Windows 95

Please refer to the README.TXT file for information on Windows 95 or Windows NT installation.

Joystick Drivers

If you have a joystick hooked up to your PC, you can use it within *Sail 95*. First, however, you need to install a Windows driver for it. The directory to which you installed *Sail 95* contains a subdirectory called "IBMJOY." This contains a Microsoft joystick driver for Windows. The following steps will install the driver.

- Open the Control Panel.
- Double click on "Drivers."
- Select "Add ...."
- Select "Unlisted or Updated Driver."
- Use the browse command to locate the IBMJOY subdirectory of *Sail 95*.

- Click "OK" until the driver is installed and the joystick calibrated.

The "IBMJOY" subdirectory also includes two text files from Microsoft: "JOYSICK.TXT" and "LICENCE.TXT." These can be read by using Windows' Notepad or any text editor.

Performance Issues

Please read the following carefully.

- Video card speed is extremely important, especially on a faster machine. Your CPU may be able to calculate frame information in 50 mSec, but if your video card is taking 200 mSec to put the images on the screen, you're only going to see a frame rate of 4 fps. We strongly advise the use of the fastest video card you can obtain. This will stand you in good stead for the future as applications make greater and greater demands on a computer's graphics capabilities. If you are considering a new machine, ensure that it has local bus capabilities.

- CPU speed is also important. *Sail 95* takes about 25 mSec of CPU time per frame on a Pentium machine. This number increases to about 100 mSec on a 486DX33. If getting a new machine, always get the fastest CPU that is still reasonably priced. Right now this means a Pentium. In 1993 and the first half of 1994, this meant a 486DX66. The difference in price today between a 486DX66 system and a Pentium system is only a couple hundred dollars.

- Hard drive speed is also important and will affect the rate at which the screen updates when one of the boats in *Sail 95* turns. Today's larger hard drives have access speeds fast enough that this should be imperceptible. Ensure that you are using some form of disk caching (see below). Again, if getting a new machine, ensure that it has local bus capabilities.

- *Sail 95* has been tested using both Stacker 4.0 and Microsoft's DoubleSpace disk compression. Neither of these products had any significant effect on *Sail 95* performance.

- A full defragmentation of the hard drive to which *Sail 95* is installed is recommended. This is best done before installation, but can be done after installation by deleting all *.shp files in the shp subdirectory, performing the defragmentation, and then recreating the *.shp files by running *Sail 95's* SETUP.EXE. The idea here is to make sure that all those 1586 "SHP" files are in the same area of your hard drive as each other. Refer to your MS-DOS or other software documentation for details.

- The use of 32-Bit file access (under Windows for Workgroups), SMARTDRV.EXE or other disk caching utility will improve performance greatly. A 512K to 1Mb disk cache should be sufficient. Refer to your MS-DOS or other software documentation for details. Ensure that you leave enough RAM available for *Sail 95* to swap completely into actual RAM. If you see a lot of HDD activity while the

simulator is running (not just when one of the ships is turning, heeling, or changing sail settings), this indicates insufficient available RAM. *Sail 95* will run extremely poorly if it needs to access a swap file during play. The “About” Item under the “Help” menu of the Program Manager will tell you how much memory is available for Windows. The difference between this number and the sum of your computer’s RAM and your swap-file size will tell you how much memory is being used by Windows for other things. If this represents a large amount of memory (greater than a couple of Mbs) you may want to try to free up some more memory because of the overhead involved in managing the swap file. A large number of installed fonts is a common culprit. A large disk cache is another possibility. Exit Windows and type MEM -C | MORE at the DOS prompt to ensure that the missing memory is not being used by any DOS utilities. Reconfigure your CONFIG.SYS and/or AUTOEXEC.BAT files if necessary. If necessary create a “clean boot” disk that uses a stripped down CONFIG.SYS and AUTOEXEC.BAT. Rmber that HIMEM.SYS is necessary for Windows. Examples of these two files are included in the “boot” subdirectory of *Sail 95*. It will probably turn out that something in Windows is using a lot of memory. Unfortunately, there is no easy way within Windows to see what exactly is using up what memory. The SYSTEM.INI and WINDOWS.INI files are about the best places to look to see what is being initialized. This is difficult. There are, however, a number of books and a few utilities that deal with cleaning

up the Windows .INI files. If all else fails, you can delete all your Windows files and reinstall Windows. You may have to reinstall some of your software after this as well.

The main advantages to using Windows NT or Windows 95 lie in the greater efficiency of those operating systems at performing system tasks. In practical terms, this means that you will see not only a slight improvement in frame rate, but faster update of mouse input, faster disk access, etc. This is most noticeable on slower machines.

Performance on some machines can be improved slightly by turning sound and/or music off. This is particularly true if your sound card uses your computer's resources to perform any of its tasking. (At this time few cards do this, but there are some lower-priced cards starting to come out that offer wavetable playback of music by using the computer's disk drive for wavetable storage and/or the computer's CPU for processing.)

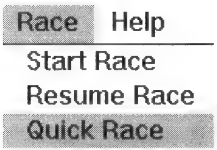
Quick Start

10 Minutes to Victory

Sail 95 is enjoyable on many different levels. Even if you enjoy reading computer manuals, we recommend that you start off by jumping into a race as described in this chapter. After you get a feel for the simulator's basic interface, you can return to this manual to explore some of the program's more in depth capabilities.

Open *Sail 95* by double clicking on its icon in the Program Manager. (You could probably have figured that one out.) After a brief introduction set to some music, the program will load a number of images it needs from your hard drive into RAM. Depending on the speed of your computer and the performance of your hard disk drive this can take anywhere from 15 seconds to several minutes.

If you have a joystick connected to your computer and have installed the optional Windows joystick driver, you will be asked if you want to use your joystick. If you answer "Yes," there will be a brief calibration routine.



After the images have finished loading, select "Quick Start" from the race menu. This will put you at the start of a short leg length abbreviated course with only two legs: a beat to windward and a downwind finish. Your red yacht starts the race a few seconds before the gun in a neutral position to your opponent.

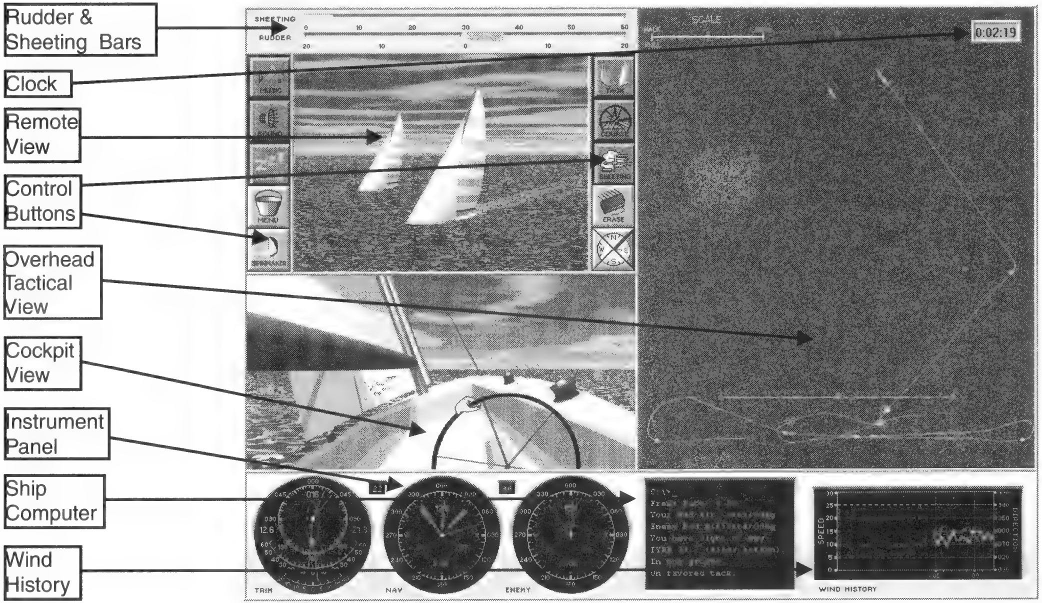
Along the two sides of the three-dimensional view in the upper left portion of the screen, you will see buttons that control various aspects of the simulator. Click the three buttons at the top right hand labeled “Tack,” “Heading,” and “Sheeting.” Using these three buttons simultaneously puts the computer in full control of your ship. After you engage these buttons, you can relax for a while and enjoy the action.

If you leave your ship on computer control, it should finish this quick race in about 10 minutes. You may, however, pause the action at any time by pressing the pause button on the left hand side of the top left view.

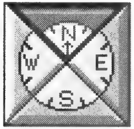
☞ Be careful not to click the right mouse button yet! Doing so will engage a secondary form of yacht control that will be described later. If you inadvertently click the right mouse button, click it again a second time to return to normal control and then reengage the three automatic control buttons.

The Screen

Let's take a quick look around the screen:



As you can see, three main views and an instrument panel are shown.



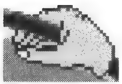
The remote view in the upper left shows your boat and any action around it from a viewpoint of about 250 feet away and a height of about 75 feet. You can change the position from which you look at this view by clicking any of the four directions on the lower right control button.

The large frame on the right hand side of the screen shows an overhead view of the entire race course. This is the view you would see from a height of about 3000 feet above the water. North is always at the top of this view. A blinking mark indicates your next turning point with the color indicating the passing side: blinking red means you should pass the mark to the right and blinking green means you should pass the mark to the left.

Manual Steering

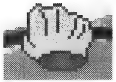
The view from the cockpit in the lower left portion of the screen is one of the areas from which you can control your ship. If you move the cursor into this screen, you will notice that it turns into either a hand or a crank, depending on what side of the screen the cursor is on.

☞ When the cursor changes into a right hand, clicking the left mouse button will turn the yacht's wheel and rudder to the right. When the cursor changes into a left hand, clicking the left mouse button will turn the wheel and rudder to the left. Continuing to hold down the left mouse button or repeatedly clicking it will turn the wheel and the rudder further in the same direction and increase the rate at which the ship turns.



☞ When you manually steer the ship, the automatic steering and tacking buttons will disengage.

You can tell in which direction and by how much the rudder is displaced by looking at the green rudder bar at the top of the screen.



☞ Until the rudder is centered, the ship will continue to turn. To center the rudder, either turn the wheel back in the opposite direction or move the cursor over the center of the wheel so that it turns into a centered hand and click the left mouse button. The latter method is easiest.

If you get into trouble, or don't know what to do, reengage the automatic controls and let the auto helm controls steer you back on course.

Other Steering Methods

There are two other means to manually steer the yacht: joystick control and direct mouse control.

Joystick

Joystick steering is very simple: push the joystick left and the rudder will move left, push the joystick right and the rudder will move right. Centering the joystick centers the rudder. The amount of joystick displacement determines the rudder displacement. Moving the joystick forward and aft controls the sheeting: see below.

Direct Mouse Control

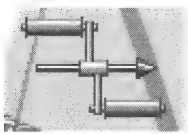
This is the easiest and most precise method of rudder control after you get the hang of it. If you click the **right** mouse button, the cursor will jump up to the top of the screen inside the rudder and sheeting bars window. Once there, merely moving the mouse left will turn the rudder left and moving the mouse right will turn the rudder right. Clicking the right mouse button a second time will jump the cursor back down to the main screen.

The trick to this method is remembering that you've engaged this form of control. If you are using this control method and you try to move the mouse to activate a control button without right clicking a second time first, you will inadvertently put your yacht into a very sharp and unplanned turn.

Sheeting Control

For the time being we recommend that you keep the auto-sheeting button engaged and let the computer control the sheeting. If you wish, however, you can manually control the ship's boom angle three ways.

Cockpit Winches



If the cursor is moved down into the cockpit view to the side of the ship the mainsail is on (away from the wheel), it will turn into a grinder's winch. If it is moved all the way to leeward (the far side of the sail), it will have a red arrow through it pointing out; closer in it will have an inward pointing arrow.

Clicking the left mouse button when the arrow is pointing out will release the sail five degrees for each click; clicking the left mouse button when the arrow is pointed in will pull the sail in five degrees for each click. You can determine the approximate sheeting

angle by observing your yacht in the remote view. The exact sheeting angle is shown by the yellow sheeting bar at the top of the screen.

☞ If the sheeting bar at the top of the screen shows red, you have let the sheet out much too far. The red represents the loose line as your mainsail flaps directly into the wind. (If you have an audio card, you will also hear the sound of the sail luffing.)

☞ Any manual sheeting input will disengage the automatic sheeting control.

Joystick Sheeting Control

If you have an active joystick, moving the joystick forward will let the sail out and moving the joystick aft will pull the sail in. Returning the joystick to neutral does not affect the sheeting change you have just made. The amount of joystick displacement determines how far in or out the sail will move. To release a tightly sheeted sail fully or fully tighten a loose sail will, however, require you to "pump" the joystick multiple times in the direction you wish the sail to go.

Mouse Sheeting Control

When you right click the mouse to engage the direct mouse rudder control, you also enable direct mouse sheeting control. While the cursor is within the sheeting and rudder bar window at the top of the screen, pressing and **dragging** with the **left** mouse button will enable you to change the sheeting angle. When you have set the sheeting angle you want, release the left mouse button. Remember, you're still under direct mouse rudder control until you right click a second time.

Changing Sails

Sail 95 lets you select one of two types of foresails: a 150% genoa and a combination asymmetric/symmetric spinnaker. (Only in a computer does such a sail exist: the actual IACC yachts carry a number of different jibs and spinnakers.) So far you have probably been sailing around with the genoa. This is a good all purpose sail but for best downwind sailing performance you'll need to select the spinnaker.

To change sails to the spinnaker, click the control button labeled "Spinnaker." Deselecting this button will reselect the genoa.

You may have noticed that you couldn't let the sheeting out past 40° with the genoa raised. This is *Sail 95's* way of informing you that you need to change sails. Likewise, you will be unable to sheet the sail in past 20° with the spinnaker selected. A genoa at these larger sheeting angles is inefficient; a spinnaker at the lower sheeting angles would collapse.

More Information

This should give you enough information to play around with the simulator a bit. For an in depth discussion of all the menus, buttons, and instruments, see the chapter "*Sail 95* Reference."

Sailing Theory

How Sailboats Sail Upwind

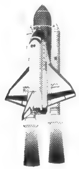
The same principles that enable NASA to launch the space shuttle into orbit enable a sailboat to sail upwind.

It seems obvious how a sailboat sails downwind: it is pushed along by the wind in its sails. Less obvious is how it can sail upwind or how some sailboats can sail faster than the wind. Let us see how this can be.

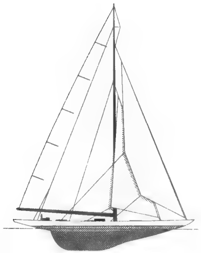
Some Basic Physics

Three hundred years ago, Sir Issac Newton formulated three basic laws that pertain to the motions and accelerations of all objects. These are that if there is no net force on an object, it will not experience any acceleration or deceleration (First Law); that if a net force is exerted on an object it will accelerate proportionately to that force (F=ma, or the Second Law); and that for any force exerted on an object an equal but opposite force must be exerted by that object onto whatever exerted the force (Third Law). Right now we'll look at the third law, although later on we'll come back to the first two.

A direct consequence of the Third Law is the conservation of momentum. (Momentum equals mass times velocity.) The conservation of momentum tells us that if the velocity of one thing is somehow changed (in either magnitude [linear momentum] or direction [angular momentum]) that the velocity of something else must also change accordingly. Moreover, a small change in velocity of a massive object can be balanced by a large change in velocity of a lighter object and *vice versa*.



This is, of course, how a rocket engine functions: hot gases are expelled at a high velocity out of the back of the engine and, in reaction to this, the rocket is accelerated forward. Compared to the rocket's mass, the escaping gases are light, but their velocity is high enough that the rocket is accelerated strongly enough to enable such engines to send men into earth orbit and beyond.



When a sailboat sails, the opposite occurs. Because of its large sail area, a sailboat can change the velocity of a huge amount of air by accelerating it a small amount in direction or speed. In reaction to this the sailboat can experience a tremendous force. This is how a sailboat can sail faster than the wind.

Because the change in velocity that a sailboat imparts to the air hitting its sails can be a change in the **direction** in which the air is moving, a sailboat can experience a large driving force even when it is sailing **into** the wind.

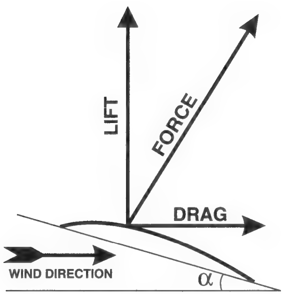
An Experiment

This phenomenon is easily experienced in everyday life. If you stick your hand out of the window of your car when you are driving and hold it at an upwards angle to the wind, your hand will deflect the air hitting it in a downwards direction. Your hand will experience a force pushing it upwards in equal reaction to your hand's acceleration of the air downwards.

A Simple Explanation

This is how sailboats sail and why airplanes fly. The normal explanation given for airplane flight, that the air traveling over the top surface of a cambered wing travels faster than the air traveling over the lower surface, causing a pressure differential in accordance with Bernouli's Principle, is confusing and not entirely accurate. (I flew jets for the USAF for six years and I can assure you that supersonic aircraft can still fly despite having symmetrical airfoils.) The real reason airplanes stay up is that when they fly they push air down. The reason sailboats can sail at an upwind angle is because they push air sideways.

Lift and Drag

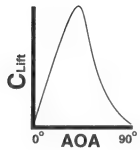


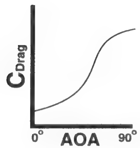
Whenever a fluid flow exerts a force upon an object in a direction perpendicular to the uninterrupted flow of that fluid we say that **lift** is generated. When a force acts in the direction of the fluid flow, we call the force **drag.** We call the object interrupting an airflow an **airfoil** and an object interrupting a water flow a **hydrofoil**. The study of fluid flow around an object is for air called **aerodynamics** and for water called **hydrodynamics**.

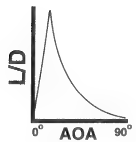
Because lift and drag are defined as being perpendicular to one another, any force acting on a foil can, using trigonometry, be divided into a lift component and a drag component. By separating the force into these two components we can study the relationships between lift, drag, the shape of the foil, and the angle of the foil to the flow.

For a sailboat, drag is not always bad. For example, when it is sailing directly downwind, drag represents the entire driving force for the boat. When it is trying to sail upwind, however, lift will both drive and heel the boat, while drag will only impede it.

The angle of the foil with respect to the flow is referred to as **angle of attack, AOA**, or the greek letter α (alpha). By normalizing the values for lift and drag to the magnitude of the total force (all drag) acting on a standardized cylindrical foil, we obtain two coefficients, C_L and C_D, for lift and drag that we can directly compare with other values for different airfoils and/or different α's. The relationship between α and the lift coefficient is called a lift curve, and that between α and the drag coefficient a drag curve.

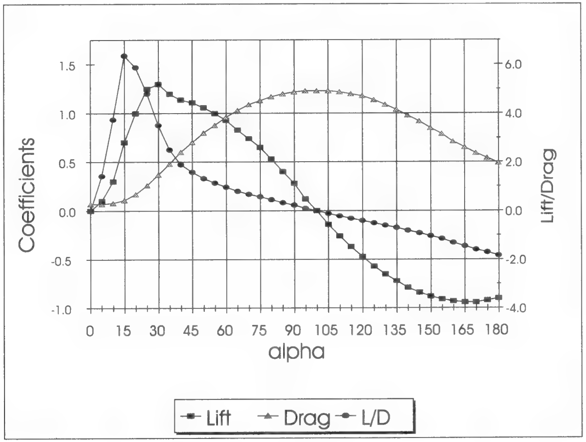






Certain characteristics of these curves are similar for all airfoils. There is an α at which the lift coefficient is maximum and an α where the drag coefficient is maximum. There is also an α where the ratio of lift to drag is maximized. This L/D_{MAX} represents the best gliding angle for an aircraft and the best upwind sail angle for a sailboat. If you look at these typical lift and drag curves, you will notice that the lift coefficient gradually increases until reaching its maximum value after which it falls off sharply. At this same point, the drag rises sharply. This phenomenon is due to the airflow over the back side of the airfoil suddenly becoming turbulent. The air can no longer "turn the corner" around the sail. (Remember that it is this deflection of the air mass that is creating the lift.) There is a "sweet spot" right before this happens where the lift is almost maximized and the drag has not yet started to rise too sharply. At this point the ratio of lift to drag is maximized. This is where one wants to try to sail when sailing upwind.

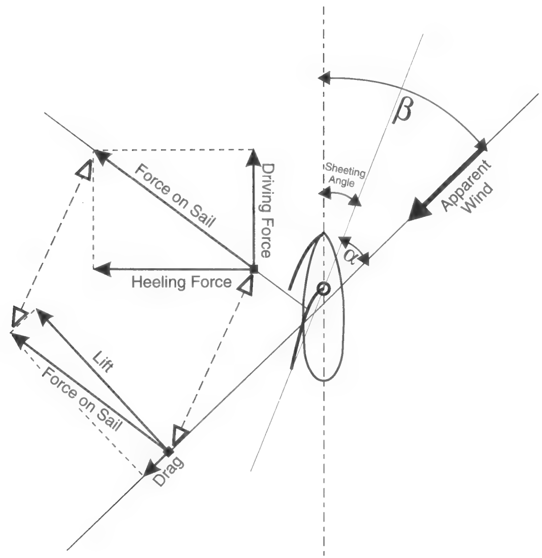
Below this point, lift falls off; above this point lift falls off and drag increases. Additionally, since a sail is made of cloth, below a certain α a sail will no longer hold its shape and will luff, or flap, in the wind. (Some high performance catamarans actually have rigid wing sails to improve the shape of the aerodynamic foil.)



This is a plot of the actual lift and drag curves used by *Sail 95.* We can look at this graph and see that the maximum lift to drag ratio occurs at an α of 15^o while the maximum lift occurs at 30^o. When we sail upwind, we want to keep α between about 15^o and 20^o.

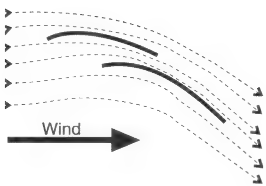
All this does not, however, mean that you can sail to within 15° of the wind. There are two reasons for this: The angle of the wind on the sail (α) is not the same as the angle of the boat to the wind, and the wind that the boat experiences is not the same as the true wind but is changed due to the motion of the boat itself.

The actual angle of the sail to the wind is the difference between the angle the boat is sailing to the apparent wind (β) and the angle the sail is set at (the sheeting angle).



If you look at this diagram, you will see that the driving force on the boat is less than the lift created by the sail when sailing upwind. Also notice the large amount of heeling force generated by lift. This heeling force is counteracted by a boat's keel and the weight of the crew, but it can also be reduced by easing the sail out. When sailing upwind in strong winds, it is necessary to let the sail out a bit to achieve the best upwind boat speed.

Foresails



For reasons not entirely known, the use of a second sail in front of a sailboat's mainsail increases the lift on the mainsail. Such sails are called **foresails**. The increase in the efficiency of the mainsail caused by such a sail may be due to the foresail directing wind over the back side of the sail and delaying the turbulent separation that occurs at large angles of attack, or it may be due to a funneling effect whereby the air moving through the slot between foresail and mainsail is accelerated, causing reduced pressure or suction behind the mainsail. The phenomenon is probably due to a combination of these factors.

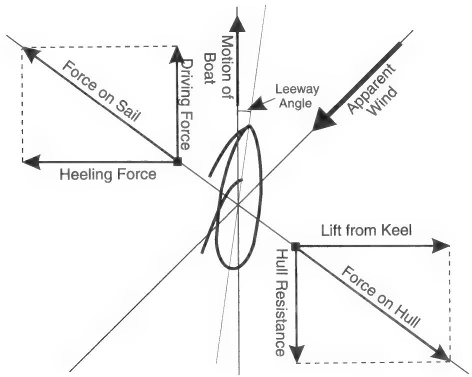
A triangular foresail similar in shape to the mainsail is called a **jib**. It is used when sailing into or across the wind. A large balloon type foresail, whose function is to catch a large amount of air and increase the aerodynamic drag on a boat is called a **spinnaker**. It is used when sailing at a downwind angle. There are many variations and combinations of these two types of sails: in *Sail 95*, however, you only need concern yourself with two: an all-purpose upwind jib (called a **genoa)** and an all-purpose downwind spinnaker.

In an actual sailboat the relative sheeting of the mainsail and the jib is critically important. In *Sail 95*, however, your job has been made much easier. Whenever you adjust the mainsail, the foresail will be automatically trimmed accordingly.

Hull Resistance

If there was no force to balance the force the wind exerts on the sail to drive the boat, a sailboat would, in theory, accelerate indefinitely (as long as the relative wind remained in a position to fill the sails.) This is obviously not the case, and a sailboat's forward driving force is balanced by the water resistance on its hull. This resistance is quite large: reduce it greatly, as in the case of an ice boat, and you will have a sailing craft capable of speeds in excess of 100 mph in a 20 knot wind!

The large amount of sideways heeling force that a sailboat experiences is balanced by an equal but opposite force on its keel. This is generated by the keel creating hydrodynamic lift as it moves through the water at a certain small angle called the ship's leeway and pushes water sideways to leeward. In *Sail 95*, you needn't worry about leeway: where the boat is heading is where it will go.



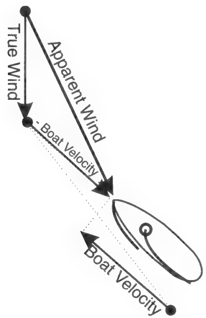
A boat's hull resistance is a product of many factors, and always increases as speed increases. Above a certain speed it increases dramatically due to wave formation around the hull. The point where this increase occurs is called the **hull speed** and is mainly a function of waterline length. (It is approximately equal to 1.3 x $\sqrt{LWL}$.) In the case of an IACC yacht this speed is around 11 knots. It is possible to sail faster than this speed,

however greater and greater driving forces are needed. What this means in practical terms is that the ships modeled in *Sail 95* will accelerate quickly up to a speed of between 10 and 12 knots, and then much more slowly after that. It is possible in some boats to accelerate completely past the point of wave resistance so that the boat's hull lifts partially out of the water and it rides on its own wave. Such behavior is called **planing** and is most often seen in small lightweight sailing craft or multihulled vessels. In strong wind conditions, the IACC class is also capable of this behavior, and can achieve speeds over 20 knots in enough wind. (The current yachts are, however, optimized for the light conditions off San Diego. They would undoubtedly suffer equipment failures if they were sailed in extremely strong winds. If the Cup moves down to Australia again to be competed for in *Freemantle Doctor* strength winds we would see designs capable of these speeds.)

Apparent Wind

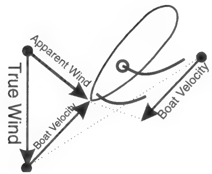
Whenever a sailboat is moving, the wind that it experiences is affected by the boat's motion. If you stick your hand out of a car window when driving along at 30 mph, you will feel a 30 mph wind on your hand even if it is a still day. In the same manner, the wind felt by a moving boat is different from the actual wind over the water. The speed and direction of the wind over the water is referred to as the **true wind** while the wind that a sailboat experiences is called the **apparent wind**.

Apparent wind is the vector sum of the true wind and the inverse of the boat's velocity. In simple terms this means that the apparent wind differs from the true wind in both heading and speed.



When a boat is sailing upwind, the speed of the apparent wind is always greater than that of the true wind; when sailing downwind, the apparent wind speed is usually less than that of the true wind. The direction the apparent wind comes from is always shifted forward of that of the true wind. In the case of land and ice boats (which can sail as fast as four times the true wind speed), this shift is so great that they are always sailing close hauled.

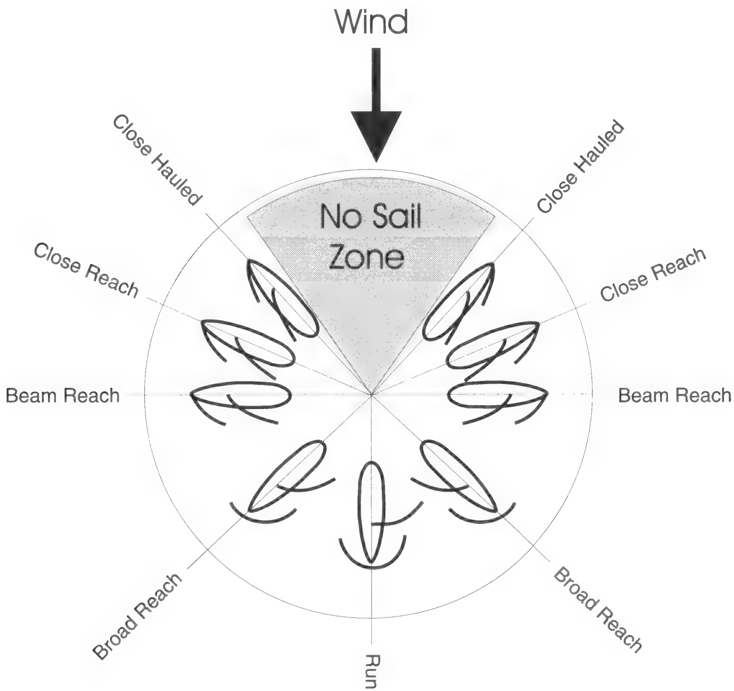
Since the apparent wind is shifted forward, the minimum angle to which one can sail to the true wind is increased. In the case of the IACC yachts modeled in *Sail 95*, this angle is between 25° and 35° depending on the wind speed. The optimal upwind sailing angle is larger yet.



When sailing downwind, the speed of the apparent wind is reduced. If a boat were to be sailing directly downwind at 10 knots in a 15 knot breeze, the apparent wind it experienced would be only 5 knots. Because of this, in a high performance yacht it is advantageous not to sail directly downwind but instead to sail downwind at an angle.

Points of Sail

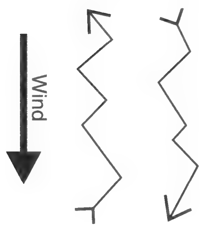
A ship's sailing direction relative to the true wind is called its **point of sail**.



We've just seen that there is a zone heading into the wind where a boat cannot sail. Sailing right at the edge of this no sail zone is called sailing **close-hauled**. The sail is sheeted in as closely as possible and the ship sails at an angle of between 35^o and 50^o to the true wind. Sailing a little further off the wind, at an angle of between about 50^o and 70^o, is called a **close reach**. Here you will need to let the sail out 5^o to 20^o (depending on the wind speed.) Sailing perpendicular to the true wind is called a **beam reach**: let the sail out 10^o to 40^o. Sailing off the wind between about 110^o and 160^o is called a **broad reach**: here you will want to use your spinnaker and let the mainsail out 40^o to 60^o. Sailing directly before the wind is called a **run**. In a high performance boat, you don't actually want to run because the apparent wind would drop off too much.

Performance Data contains charts showing recommended sheeting angles for various points of sail at different true wind speeds.

Tacking

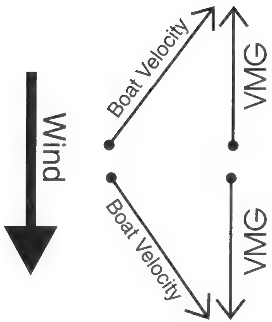


Since a sailboat can't sail directly upwind, it must instead follow a zigzag course if it wants to reach a point that is directly upwind from it. As we just saw, it should also follow a zigzag course when it is sailing to a point directly downwind. The process of sailing to a point in this manner is called **tacking**. The process of turning the bow of a boat through the wind is also called tacking; turning the stern of a boat through the wind is called **gybeing**.

If a boat is sailing such that the wind is coming from the right side of the boat, it is said to be on a **starboard tack**. If the wind comes from the left it is on a **port tack**.

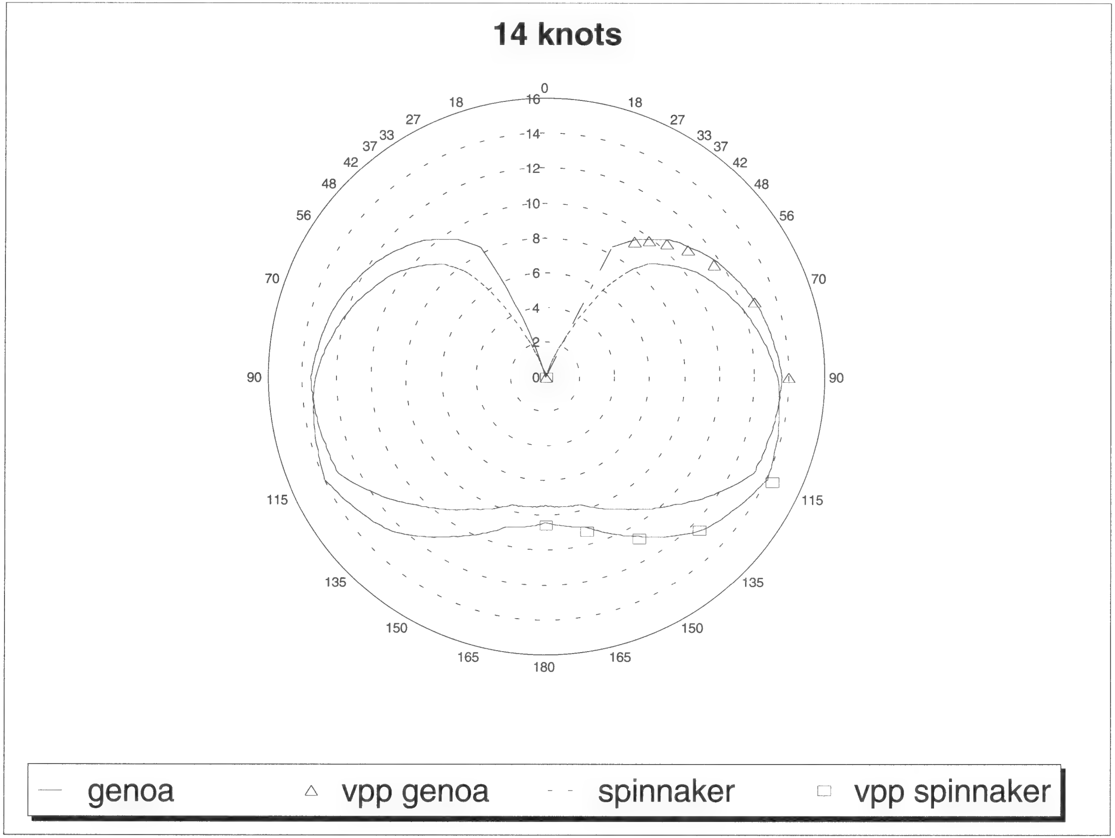
Velocity Made Good

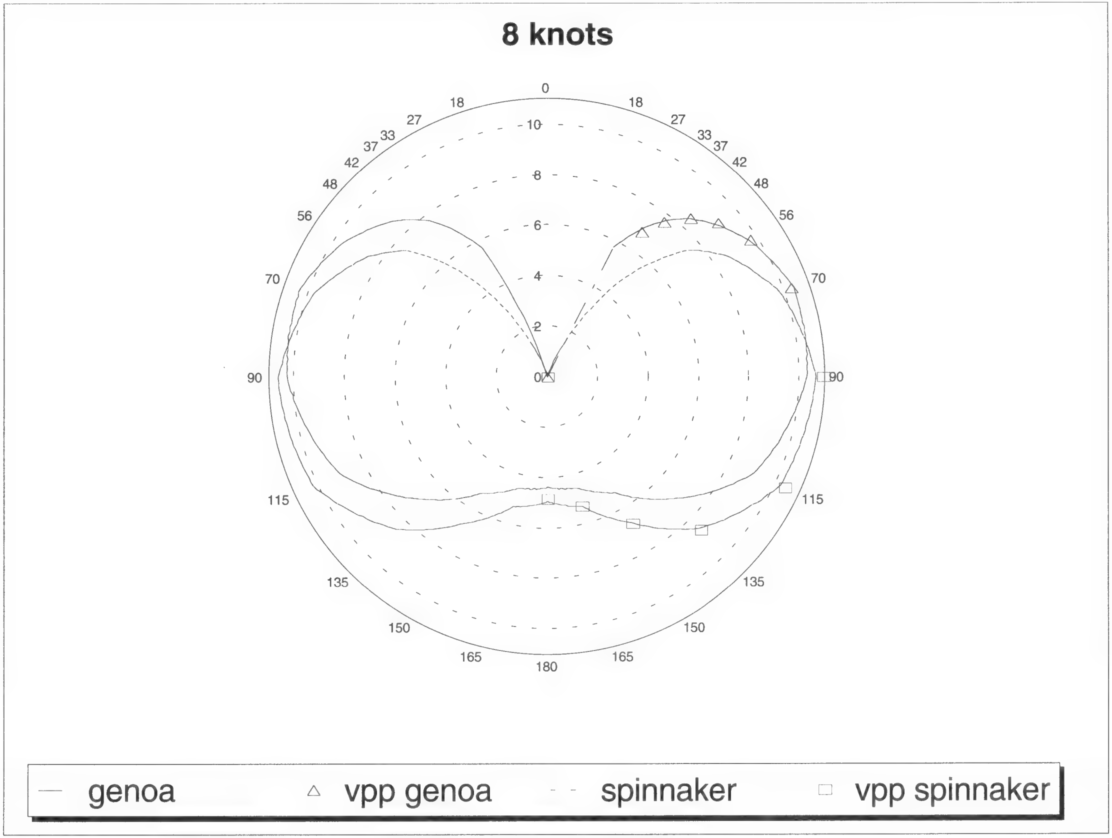
When racing we are most often concerned with getting directly upwind or downwind as quickly as possible. If we sail directly into the wind, our speed would drop to nothing (we might even be blown backwards). If we sail directly downwind the apparent wind will drop off so much that we will sail very slowly. If we sail at 90° to the wind, our boatspeed might be great, but we won't get upwind or downwind at all. Somewhere between these extremes are headings that will gain us maximum upwind or downwind distances.



That portion of a sailboat's velocity that represents its speed directly up or downwind is called **velocity made good** or **VMG**. We are interested in finding the heading that maximizes this. We could try sailing a number of different courses, record our speed, and then use trigonometry to figure out all the VMGs and pick the largest one, or we can let someone else do the work for us and use what is called a polar diagram. These are generated by a breed of sophisticated computer programs called velocity prediction programs or VPPs. (The sailing model for *Sail 95* was fine tuned with output of a VPP actually used for the design of some of the 1992 IACC yachts.[1]) Let's look at some representative diagrams using actual *Sail 95* data:

1 My thanks to Peter Schween of Design Systems for providing me this invaluable data.


14 knots
0
18
27
33
37
42
48
56
70
90
115
135
150
165
180
16
14
12
10
8
6
4
2
0
genoa
vpp genoa
spinnaker
vpp spinnaker


8 knots
0
18
27
33
37
42
48
56
70
90
115
135
150
165
180
10
8
6
4
2
genoa
vpp genoa
spinnaker
vpp spinnaker

Polar Diagrams

These diagrams show what the best boatspeed will be (for both genoa and spinnaker) for any given heading in an 14 and 8 knot **true** wind. (The lines show measured *Sail 95* performance while the boxes and triangles show actual IACC VPP target speeds.) The boat's heading is read around the outside of the circle, and its speed for that heading is read as the radial distance out from from the center of the diagram. For example, heading 90^{o} to an 8 knot true wind, the best boatspeed will be a bit over 10.5 knots using the spinnaker; heading at 56^{o} with the genoa up, it will be about 9.6 knots.

The best upwind or downwind VMG can be read off of one of these diagrams as follows: hold a ruler across the diagram horizontally to find the highest and lowest points on the diagram. The highest point on the diagram is the best upwind VMG and the vertical distance to this point from the center is the actual VMG. In this case it shows us that sailing at 41^{o} to 8 knots true wind we should be able to achieve a boatspeed of 8.3 knots for a VMG of 6.25 knots. Sailing downwind, our best VMG is at a heading of 139^{o} for a target boatspeed of 8.0 knots and a VMG of 6.0 knots. By looking at where the curves for genoa and spinnaker cross, these diagrams also show when you should change foresails. In this diagram we see that at a heading greater than about 80^{o} to the true wind, we should have the spinnaker set. A complete set of these polar diagrams for a variety of wind speeds is included in *Performance Data* for your reference.

Putting It All Together

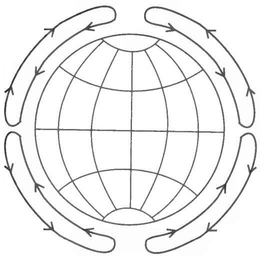
You should now have enough of a basic understanding to try sailing your *Sail 95* yacht around for a while under manual control. Try tacking upwind from the bottom of the screen towards the mark at the top of the screen. Notice what happens as you sail at various headings to the wind using different sheeting angles. Sail downwind using the spinnaker and the genoa. Refer to *Performance Data* as you do this to determine optimum headings and sheeting angles. Don't worry about the enemy boat yet. The first step to any racing success is optimal control of your yacht. Practice this for now.

The Wind

What is Wind?

Wind is what we experience when a body of air is in motion relative to the surface of the earth. It is what causes weather, and what causes sailboats to sail. Air movement on the earth is caused by several factors, some global and some local, that cause a **pressure differential** or **pressure gradient** to exist between air at different places on the earth's surface.

Global Factors



The earth's atmosphere is in constant circulation due to two main factors: uneven surface heating and coriollis forces. As you may know, warm air expands, and is therefore lighter than cold air. The equatorial regions of the earth experience greater heating than do the polar and temperate regions. This causes the air at the equator to rise (because it is heated and lighter) and the air at the poles to descend. Were the earth not rotating, this effect would result in the movement of air across the surface of the earth to be from pole to equator, and the movement of air at the upper limits of the atmosphere to be from equator to pole. Because of the rotation of the earth, however, this movement is displaced due to what is called the coriollis force. This gives rise to prevailing westerly winds in the northern hemisphere and easterly winds in the southern. The coriollis force is not an actual force *per se* but is used to describe an apparent force experienced by an observer within a rotating frame of reference.[1] We, being observers on the sur-

1 It is not within the scope of this manual to describe exactly why these coriollis forces are experienced. I will, however, describe to you a simple

face of the rotating earth, are such observers. This apparent force acts to displace any actual force acting in a direction perpendicular to the surface of the earth. In the northern hemisphere this displacement is to the right, or clockwise, while in the southern hemisphere it is to the left or anti-clockwise. These directions are also called **cyclonic** and **anti-cyclonic**, respectively.

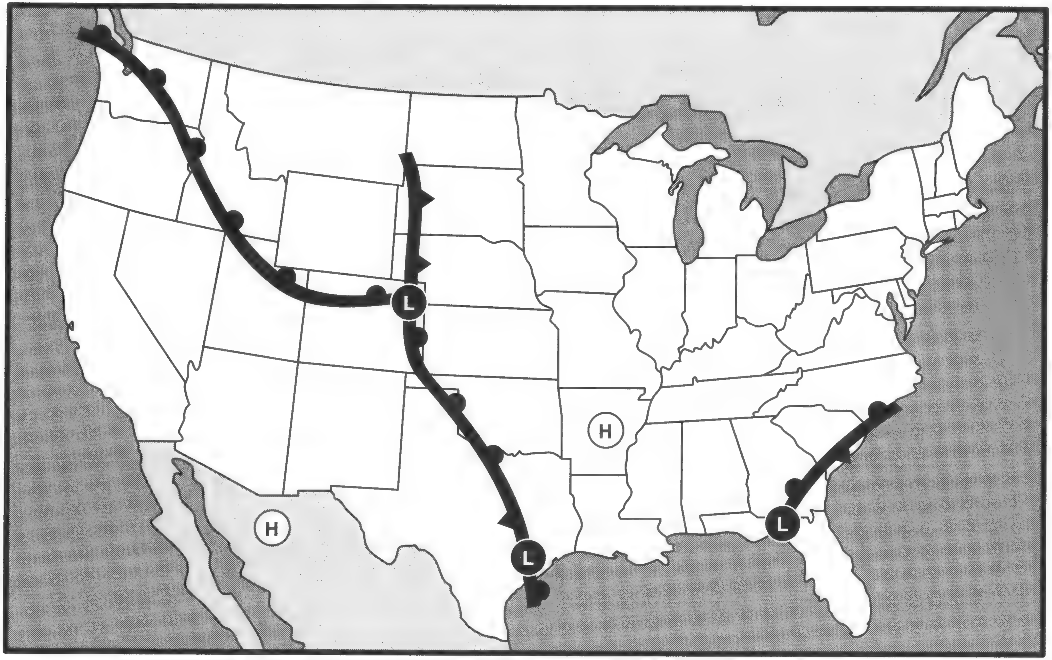
Local Factors

Local conditions also create air movement. Uneven heating of the air over different surfaces (i.e. land and water) causes convective motion and circulation. The evaporation and condensation of water cause tremendous energy exchanges. All of these factors combine to create an incredible complex system that we call weather. This system is far too complex to enable any but the most basic predictions to take place. This is why your local weather forecast is not always as accurate or reliable as you might wish. There are, however, certain characteristics that are associated with different types of air masses that can be used to predict general trends as well as local factors that, when understood, can aid in predicting what type of wind conditions will exist when sailing.

experiment that you can do to demonstrate to yourself that they do indeed exist. Sit on a rotating stool or chair and hold in your hands an axle that has been placed through a bicycle wheel. Hold the axle so that the wheel can rotate freely and then have a friend start the wheel spinning rapidly. After the wheel is freely spinning, try turning the axle to change the wheel's axis of rotation. You will find the results quite surprising.

Systems and Fronts

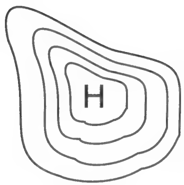
We've all heard the weatherman tell us that a high pressure system is moving in or that a cold front is approaching. Let's see what this means.



Pressure Systems

There are two types of pressure systems: high and low. Naturally enough, air will flow from an an area of high pressure to one of low pressure. Because of the previously mentioned coriollis forces, however, this flow will be displaced to the right in the northern hemisphere and to the left in the southern hemisphere. This causes a circular motion of air around a pressure system. In the northern hemisphere, air circulates in a clockwise manner around a high pressure system and counter-clockwise around a low pressure system. This circulation can be particularly strong around an area of extreme low pressure and this is what causes hurricanes and typhoons to have such strong winds.

There are some fundamental differences between high and low pressure systems. The air within a low pressure system is more stable than that within a high. As air flows into a low pressure system, the air within the system rises. As the air rises, it cools greatly due to adiabatic expansion and condensation. The cooled air is then heavier than the surrounding air and falls back down. An equilibrium is reached and there is little mixing of the air at the surface and that of the upper atmosphere. Any moisture in the air will form stratified clouds and any wind patterns on the surface will be fairly steady.



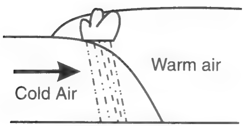
In a high pressure system on the other hand, the initial air flow is from higher altitudes to low. Because this air is cooler than that of the air on the surface, it is also heavier. This denser air continues to flow out and there is a great deal more mixing of the surface and atmospheric air. Because the subsiding air in a high pressure system is also dry, we associate high pressure with clear skies, good visibility, and breezy conditions.

In the case of an extreme low pressure system, the great amount of heat exchange due to water condensation as the air in the center of the system rises can cause severe weather. A thunderstorm is a highly localized example of this. Enough energy is exchanged in the form of heat within a thunderstorm to power an entire city!

When a strong pressure gradient exists between a high and low pressure system, the wind can be quite steady and quite strong. This is sometimes called a **gradient wind**.

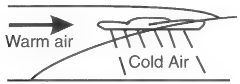
Frontal Systems

Another method of classifying air masses is by their temperature relative to other air masses on the surface. When there is an abrupt difference between two such systems we say that a front exists. If this change consists of cold air flowing underneath warmer air, we call it a **cold front**. The case of warmer air displacing colder air is called a **warm front.** When warm and cool air masses are mixing but the area where this mixing is occurring is not moving, an **occluded front** or **stationary front** is said to exist.



Cold Front

In a cold front the advancing cold air is denser than the warm air into which it is advancing. The cold air will tend to slide under the warmer air, displacing the warmer air upwards. If this warmer air contains any moisture, it will condense and cause precipitation. This lifting of the warmer air mass can cause localized severe low pressure type weather. It is not unusual for a cold front to manifest itself as line of thunderstorms. Additionally, the shift in surface winds experienced as a cold front passes can be quite abrupt and has lead to numerous aviation disasters.



Warm Front

A warm front is generally much more spread out in its transition than a cold front. As the warm air meets the cooler air it gradually mixes and rises over the cooler air. Stratified clouds are formed as this happens, and any precipitation tends to be widespread and steady.

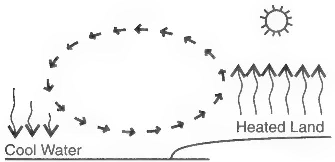
An occluded front contains unpredictable elements of both warm and cold fronts. In addition to their potential for creating unpleasant weather conditions, occluded fronts can also stay over one place for extended periods of time.

Local Patterns

Systems and fronts are large scale phenomena that influence local weather patterns. In addition to these influences on weather, localized conditions are also important. This is especially true near a coastline where widely different surface conditions exist. This is where most of us do our sailing.

The Sea Breeze

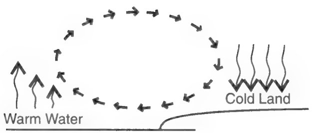
In the heat of summer, we all like to escape to the shore for the comfort provided by the cool breeze off the water. When sailing, this breeze is what most often provides us with the wind to fill our sails. Sea breezes exist along a coast whenever there is a significant temperature difference between the air over the land and the air over the water.



On Shore Breeze

The mechanism behind the sea breeze is quite simple. Because water heats and cools far more slowly than land, a large difference in temperature between the air over the water and the air over the land is created. In the summer, because the water is cooler than the land, this difference causes air over the land to rise and air over the water to

sink. This sets up a circulation pattern whereby the air subsiding over the water returns towards the land where it then reheats and rises again. This is the common off shore breeze experienced on warm sunny days. In some areas this sort of breeze can be quite stiff. In western Australia, for example, the sea breeze near Freemantle can be as strong as 25 knots.



Off Shore Breeze

A breeze can also occur when the water is warmer than the land. On cold cloudy days or at night the latent heat remaining in warm water will heat the air over that water which will then rise. The upper air will flow towards the land where it subsides and then flows out to sea. This is called an offshore breeze or **land breeze**. This sort of breeze will also occur, often accompanied by fog, in cold places that have warm water currents running near their shorelines. The western coast of Ireland is such an example.

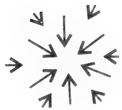
Local Terrain

Coastal terrain can have a dramatic impact upon local wind conditions. High bluffs or headlands can serve to channel an onshore or offshore breeze, increasing its strength and changing its direction. Such breezes are called **funneling** winds and often exist near natural harbors and estuaries. These types of winds are often predictable, and when racing in such areas local advice should be sought concerning them.

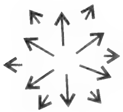
Local Clouds

When uneven surface heating occurs, localized pockets of warm air called **thermals** are created. These rise up from the surface until they cool to the temperature of the surrounding air. When they reach an altitude at which any moisture contained within them condenses, they form small puffy **cummulus** clouds. Under certain conditions, these

clouds can grow to great size and height and become **cummulo nimbus** or thunder-storms.



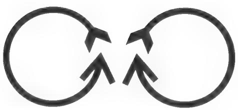
Cummulus clouds have a predictable affect on the surface winds near them. Since the air under a cumulus cloud is rising, air is sucked in from around it to fill the space vacated by the rising air. This causes the winds on the surface to be in a direction flowing in towards the cloud. Because these small clouds are quite visible, the changes in the breeze caused by them can be readily determined.



A raining cummulus cloud has exactly the opposite effect. Because the temperature of the air through which the rain falls is cooled suddenly, this air will descend rapidly until it hits the surface and spreads out. The surface winds around a rain cloud therefore move outward from the cloud.

Gusts and Veers

Only under the most dismal of sailing weather is the wind steady in either direction or strength. Instead it changes frequently. Increases in the strength of the wind are called **gusts** and decreases **lulls**. Changes in the wind's direction are called **veers**. These changes can be both steady and oscillatory.



As we have seen, air is frequently circulating. This circulation also exists on a smaller scale, within small masses of air called **cells**. These cells range in size from a few hundred yards across and up. Within an individual cell, the air rotates in a circular manner with adjacent cells rotating in opposite directions. When one of these cells reaches the

surface of the water, sudden changes in wind direction and speed are experienced. When the direction of air movement within the cell is in the same direction as that of the steady wind, a gust or lull is experienced; when the movement is perpendicular to that of the steady breeze, a veer is experienced. These wind shifts are most common when high pressure systems are predominant because more mixing of air from the surface to the air aloft is occurring.

Oscillating Winds

The pattern of these rotating cells is often fairly regular. While you can't see these cells on the water, their effects aloft can be quit visible. Many types of high clouds show extremely regular, repeating patterns, often looking like waves in the water, or "mackerel scales." When such a regular pattern of cell circulation exists near the water, the wind shifts experienced when sailing are of a cyclic or oscillatory nature. These wind shifts can be fairly predicable, usually occurring with a period of between three and fifteen minutes, and can be used to great advantage when racing.

Water Currents

Like the air, the water in which we sail is rarely still. Currents exist, especially near shores, that affect the motion of a yacht. The effect of any such current is to directly alter the absolute motion of the yacht such that it's motion represents the vector sum of the current's velocity and that of the boat through the water. Currents near shores are usually tidal, meaning that they change direction four times a day with the tides. A current flowing into a body of water as the tide rises is called a **flood** tide, as the tide recedes, the current is called an **ebb**.

Sail 95 does not model any water currents. While it would have been an extremely simple matter to do this within the simulator, I felt that such an addition would have made the simulation unneccesarily difficult for the player.

Now that you know a bit about how yachts sail and about wind and weather conditions, let's see how to put this information to use during a race.

Tactics and Strategy

The Basic Idea

The goal of any racing tactic or strategy is for you to finish the race ahead of your opponent. This can be done by either sailing faster than your opponent or by causing your opponent to sail slower than you. The former method is mainly tactical; the later primarily strategic.

Boatspeed

The most important thing in winning a race is to sail your yacht at its maximum performance. Proper boat handling and sail trim are of the utmost importance. All tacks and gybes must be made quickly and finish with your boat sailing on the proper heading for the new tack. Seriously undershooting or overshooting your new course will cost precious time. When tacking upwind, however, overshooting your new course slightly will help your yacht accelerate on the new tack.

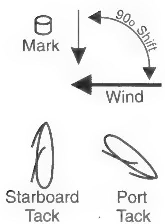
Proper Course

The proper upwind or downwind course is that which maximizes your boats upwind or downwind velocity made good (VMG). The best way to determine what heading will give the maximum VMG is to look at a Velocity Prediction Program's (VPP) polar diagrams for your particular class of yacht. Such diagrams for the yachts modeled in *Sail 95* are provided in *Performance Data*. In *Sail 95* a quick way to estimate the best upwind heading to the true wind is to subtract half of the true wind speed (in knots) from 43^{o}. (i.e. if the true wind speed is twelve knots, you will realize your best upwind VMG if you sail 37^{o} off the true wind.) When sailing downwind, keeping your heading

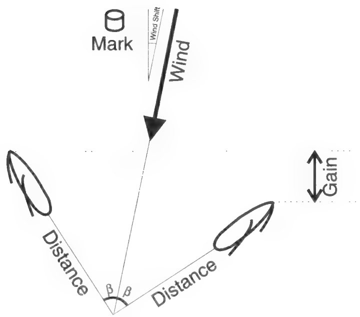
to the true wind around 140^{o} will get you close to your best downwind VMG. (Make sure you're using your spinnaker!)

Preferred Tacks

Sailing courses are laid out such that the upwind legs are sailed directly into the wind as best as can be determined by the race committee at the time of the start of the race. As we just saw in the last chapter, however, the wind is rarely consistently from one direction: it shifts around somewhat in heading. If you are sailing upwind and the wind shifts so that it is heading from closer to the bow of your boat, the shift is called a **header**. This is disadvantageous: you will have to fall off from your course towards the upwind mark. If the wind shifts away from your bow, the shift is called a **lift**. This is to your advantage: you can head up and sail closer to the mark. Whenever the wind is heading from a direction other than straight down the race course (which is almost always), one tack will be headed and the other lifted. The tack which is lifted is the **preferred tack** and a boat on this tack can gain great distance over a boat on the headed tack.



An extreme example can help illustrate why this is important. Let's say that a course is laid out top to bottom north to south: the race committee expects the wind to be coming from due north. (This is how all the courses in *Sail 95* are laid out: no need getting confused about compass headings.) A couple of minutes into the race, the wind shifts a full 90^{o} such that it is now blowing from due east. A boat that is on a starboard tack could now sail directly to the mark on a beam reach. A boat on a port tack could no longer sail towards the mark at all!



Gain by Preferred Tack

It is very important that you try to sail as much as possible on whichever is the preferred tack. When you think of tactics, think of tacks. In *Sail 95*, since the courses are always laid out with north at the top of the course, when the true wind is from a heading greater than 000^o a starboard tack is favored; when the true wind is from less than 000^o (359^o or less), a port tack is favored.

If the wind is always from one side of the course or the other, you cannot always sail on the preferred tack. At some point you have to tack over onto the other tack to fetch the mark. (An exception to this would be if the wind shift was greater than your best upwind VMG angle. If this were to happen, however, the race committee would change the course.) If, on the other hand, the wind is shifting back and forth from one side of the course to the other it is possible to sail the entire leg always remaining on the preferred tack. Doing this is called sailing **in phase** with the wind shifts.

As mentioned in the chapter on theory, a high performance yacht sailing downwind also needs to tack in order to maintain its best downwind VMG. The discussion of preferred tacks therefore also applies to downwind racing legs with the following exceptions: in *Sail 95* if the true wind is coming from greater than 000^o, a port tack is favored; if from less than 000^o, a starboard tack is favored.

Boatspeed is extremely important. It can only be used to your advantage, however, so long as your opponent stays out of your way. We'll now look at various means by which you and your opponent can interfere with each others' ability to maintain optimum boatspeed.

Covering

As mentioned in the chapter on theory, the force that drives a sailboat is the result of that boat's acceleration of a large mass of air by its sails. If two boats are in close proximity to one another, the change in the direction and speed of the air driving one boat can affect the wind that the other boat experiences. This change in the wind due to another boat's sails partially blocking your wind can be in both direction and heading. When an upwind boat puts itself between the wind and a downwind boat it is said to be **covering** the downwind boat.

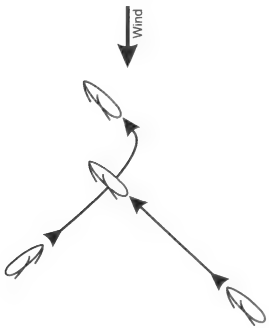
Covering on the Beat

When beating upwind, the blockage of wind experienced by a yacht directly downwind of another is mostly a change of heading. If the two yachts are on the same tack, this change of heading is experienced as a disadvantageous header by the downwind boat. As you may recall, a yacht sails upwind by moving air sideways. It is this sideways movement of the air that cause a downwind yacht to experience a header when it is covered by an upwind boat that is close-hauled.

The amount of wind shift experienced depends on both the distance between the two yachts and the angle between the true wind and the two yachts. Generally, if you are within a few hundred yards of your opponent and his relative bearing from you is within 20^{o} to 30^{0} of the true wind, you are being substantially covered. In *Sail 95* the "computer" screen on your instrument panel will tell you how much "dirty air" both you and your opponent are experiencing. Unless the tack you are on is greatly favored, you should try to tack over into clean air. Of course, when you do this, it is quite likely that your opponent will also tack to cover you. Whenever you or your opponent tacks,

the respective yacht's boatspeed suffers due to turning through the wind. The downwind yacht hopes that eventually she can get free of the upwind yacht and into clean air. Two yachts engaged in frequent tacks of this sort sort are said to be engaged in a **tacking duel**.

The Slam Dunk



Another covering maneuver occurs when two boats have previously split tacks and are reconverging. (To **split tacks** means the two boats go off in separate directions on opposite tacks.) When the two boats come back towards each other, the upwind boat can tack onto the same tack at as the downwind boat, timing her tack so that she matches her opponent's tack when her enemy is directly downwind of her. This is called a **slam dunk** and requires perfect timing on the upwind boat's part.

The downwind boat can defend against this by also tacking when she sees her opponent tacking. This will put the boats onto divergent tacks again. Of course if this sort of tactical maneuvering is occurring in conjunction with a regularly oscillating wind shift, one of the two boats will be out of phase with the wind shifts since the two boats will always be on opposite tacks.

Covering on the Run

When heading downwind, the change in wind velocity experienced by the downwind boat is mainly a drop in wind speed: the change in wind direction is less pronounced. Note that on a downwind leg, it is the yacht that is behind that is able to cover; on an upwind leg the leader covers. While most of the previous discussion also applies to covering on a run, it is difficult to overtake on a run when covering. Any overtaking on

a downwind leg is usually done by splitting tacks and getting better wind than your opponent. You can, however, close up a distance between two boats by covering on the run.

Rights-of-Way

All of the previous discussion is based upon being able to sail wherever you want to. This is, of course, not always the case. What happens if your opponent is in the way? It will not help you finish any races if you and your opponent go smashing into each other and damage what may be irreplaceable yachts. Fortunately, there are a number of rules concerning almost all possible collision situations encountered while racing. One boat always owns the **right-of-way** over the other. The boat without the right-of-way must yield to the boat with it in the same manner that a car at a stop signs yields to any conflicting traffic. Note that owning the right-of-way does not excuse you from taking necessary action to avoid a collision.[1] What it does mean, however, is that if you or your opponent do not yield when required to do so, a penalty will be exacted upon the offending yacht. This can range from having to do an extra turn while on the race course to disqualification from the match.

1 The International Yacht Racing Union Rule 32.1 states: "When a collision results in serious damage, the right-of-way yacht shall be penalized as well as the other yacht when she had the opportunity but failed to make a reasonable attempt to avoid the collision."

The rules governing sailing races are prescribed by the International Yacht Racing Union. A detailed explanation of all the IYRU rules is outside the scope of this manual — there are entire works devoted to this subject alone. I will, however, describe the rules that come into play most often. All the rules described here are also implemented into *Sail 95* if you choose to race with the IYRU rules option in effect.

On Opposite Tacks

With few exceptions, a yacht on a starboard tack (the wind coming from the starboard or right hand side of the boat) has the right-of-way over a boat on a port tack. (IYRR 36)

Same Tack Overlapped

When two yachts are on the same tack and overlapped, the downwind yacht has the right-of-way over the windward yacht. (IYRR 37.1) Two yachts are overlapped when part of each yacht is ahead of an imaginary line drawn at right angles from the stern of the other. This rule is often referred to as **luffing rights**: the downwind boat can luff up into the wind and the upwind boat must keep clear.

Overlapped

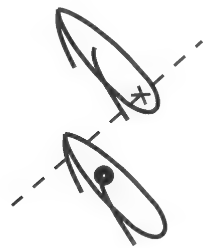
Same Tack Clear Astern

When two yachts are on the same tack, and one is clear astern of the other, the yacht clear astern of the other must keep clear. **Clear astern** means that no part of that yacht is in front of an imaginary line drawn at right angles to the stern of the other. If you and your opponent are on the same tack, you are either clear astern of him, he is clear astern of you, or you are overlapped.

Clear Astern

Mast Abeam

An overlapped leeward boat does not have the right-of-way to luff up into his opponent if he is almost clear astern. If a line drawn at right angles to the helmsman of the upwind boat is ahead of the mast of the downwind boat, the latter may not luff. (IYRR 38.2) This situation is called **mast abeam**.



Ahead of Mast Abeam

Tacking or Gybing

A yacht in a tack or a gybe must keep clear of the other yacht. (IYRR 41) This means that you cannot tack so that you interfere with your opponent, even though you would otherwise have the right-of-way over him. You can tack, however, so that when you finish your tack you gain right-of-way over your opponent and force him to alter course.

Room at Mark

An inside yacht that is within two boat lengths of a mark has the right-of-way-of-way over an outside yacht. (IYRR 42) This rule is to prevent an outside boat from forcing an inside boat into hitting or missing the mark because it does not have the room to turn around the mark. This rule only applies to actual race marks: it does not apply to marks at the start. The actual mark rounding rules are quite a bit more complicated than this. *Sail 95*, however, uses this simplification.

Returning to Start

A yacht that is returning to the start must keep clear of another yacht that has successfully started. (IYRR 44) This means that your opponent has the right-of-way if you cross the line early and have to return to below the starting line to recross the line.

Penalties

A yacht that has incurred a penalty must give way to another yacht until she has completed the penalty. (IYRR 45) In *Sail 95* penalties are incurred if you hit either a mark at any time or your opponent when he has the right-of-way. The penalty for such an error is a 360^{o} right-hand turn. Until you have taken this penalty turn, you do not have any rights-of-way over your opponent. (If you're both waiting to take a penalty turn, normal right-of-way rules apply.)

Now that you you have an understanding of some basic tactics and rules, let's see how these can be strategically applied to win a race.

Prestart Maneuvering

Before the start of any race, you must maneuver to be in an optimum position to start the race at the starting time. Ideally you want to cross the starting line just after the gun sounds on the preferred tack for the wind conditions and on the favored side of the course.

Deciding which is the preferred tack is difficult for many sail boats. Only knowing the relative wind, it is sometimes difficult to determine the direction of the true wind. A common means of doing this prior to the start is to head up directly into the wind. In this situation, the direction of the true wind and the relative wind are the same and the preferred tack can be determined. Sophisticated instrumentation can make this job easier by providing the sailor with true wind information at all times. *Sail 95* instruments provide you with such information.

During the prestart you should also try to determine which side of the course is favored. Sail across to both the left and the right hand sides of the course and note the wind on each side. You should be able to make a tentative judgment about which side is favored. Do not sail so far over that you cannot return to the line before the start.

Crossing the starting line immediately after the gun is a matter of proper timing. Knowing your boatspeed and your distance to the line, you can adjust your heading or slow your boat down by spilling wind from your sails to reach the line at the proper time. In an actual situation, you must also take into account any water current present. *Sail 95* does not, however, require you to correct for current.

The easiest way to achieve proper timing for the start is to sail back and forth a few hundred yards below the line until about fifteen or thirty seconds prior to the start. At this time, harden up into the wind and accelerate towards the line so that you not only cross it just after the gun, but also at full speed and on the proper course.

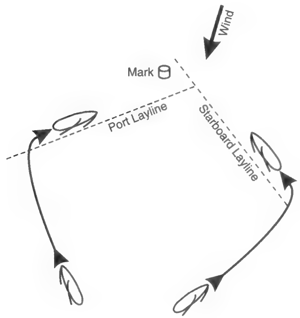
If you are between your opponent and the starting line and on the same tack, be careful that he does not establish an overlap on you and luff you over the line before the start. If your opponent is between your boat and the starting line, try to establish an overlap so that you gain the right-of way and can force him over the line early.

Fetching a Mark

After successfully starting a race, your task is to sail up to and round each course mark as quickly as possible. The first mark on a course is always upwind, so you must tack to reach it. You will want to spend as much of your time as possible on preferred tacks. You will also want to favor whichever side of the course you feel has the most wind or the most favorable shifts.

Laylines

Your primary goal should be to sail to a position where you can sail on a tack that will enable you to pass the mark. Such a course is called a **layline** and rounding the mark on a ayline is called **fetching** the mark.



There are two laylines for each mark: a port layline and a starboard layline. Depending on the direction you need to round the mark, only one of these will carry you around the mark. The other layline will require you to tack in order to round the mark. If the course features mark roundings to starboard, then a starboard layline will carry you around the mark.

When sailing to a layline, pay careful attention to how the wind direction is shifting. If you are headed by the wind after establishing yourself on a layline, you will have to make two further tacks to round the mark. For this reason it is best to allow yourself some extra room before committing yourself to a layline that will round the mark.

Downwind Marks

When on a downwind leg, you should try to sail at a heading to the wind that will maximize your downwind VMG. This means that unless there is a dramatic wind shift you will be tacking downwind. The previous paragraphs discussion of laylines therefore also applies to a downwind mark rounding. An exception is that you should not wait until past a layline to head for the mark. If you experience a disadvantageous wind shift before you reach the mark, you do not have the problem you would on an upwind leg. You can easily just fall off a bit and still round the mark.

The Finish

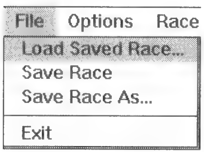
All the courses in *Sail 95* feature a downwind finish. This means that you will be tacking downwind to reach the finish line. When you approach the finish, you have the option, if need be, to fall off and run straight for the line. This could be quicker than gybeing an extra time in an attempt to maintain your maximum downwind VMG.

Program Reference

Menus

When you start *Sail 95*, it will first load some images from disk into RAM. You can monitor the progress of this by observing the two small boats at the bottom of the screen. When these boats come together, the loading is finished. The cursor will then change from an hourglass to an arrow and you will see a familiar program window with a menu bar at the top. The menu bar contains four submenus: "File," "Options," and "Help." (All the Help menu contains is an "About *Sail 95*" item.)

File Menu

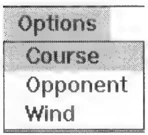


This menu has four items: "Load Saved Race...," "Save Race," "Save Race As...," and "Exit." The "Save" commands enable you to save a race in progress and then resume it at a later time. You can also save a race after you have set the race options but before you have started the race. This will enable you to resail a race multiple times with identical conditions. (Resetting identical wind conditions in the wind dialogue box will **not** create identical conditions, as there are some random factors involved when setting up the wind variables.)

Saving a race will bring up a dialog box that allows you to specify the drive, path, and filename where you want the saved file. This defaults to the SAVERACE subdirectory of the directory where you installed *Sail 95*. The save files are given a default extension of "*.RAC" although you can also save them with any extension you want. Each save file occupies less than 1K of disk space. Further uses of "Save Race" within a session will result in the current race conditions being saved to the previously opened file, overwriting it. If you wish to save a race to a different file name, use "Save Race As...."

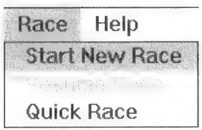
"Load Saved Race" functions in the same manner as "Save Race" or "Save Race As...." Before it will load a saved race, it will check the file to ensure that it is a valid *Sail 95* saved file. It will do this regardless of extension, so you need not use the *.RAC extensions when saving races if you don't want to.

Options Menu



The options menu lets you configure various *Sail 95* race options. The "Course" item sets the type of course, the amount of prestart time, and the course leg lengths. The "Opponent" item selects the quality of the computer controlled opponent's sailing ability, as well as the speed of his boat relative to yours. The "Wind" item lets you set a number of parameters that control *Sail 95's* wind model. These items are all covered in depth in the section "Options Dialogue Boxes."

Race Menu



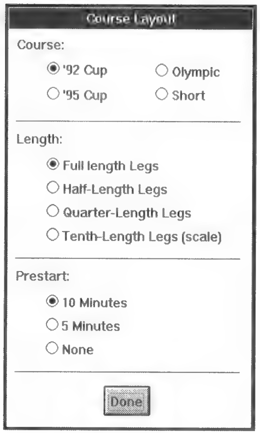
The race menu is where you actually start the simulator. This menu has three choices: "Start New Race," "Resume Race," and "Quick Race." "Start New Race" will start a new race using the options currently set in the options dialogue boxes. Any race in progress will be lost if it is not saved to disk. "Resume Race" will be dimmed unless there is a current race in progress, in which case this selection will start the simulator with the race already in progress. Use this option if you have restored a race in progress from disk or to return to a race you're currently in the middle of. "Quick Race" will start a new race with short course and short leg options. Any race in progress will be lost. Use this option if you want to sail a quick race without setting any options.

Options Dialogue Boxes

Sail 95 contains a number of flexible options for configuring the race course, the quality of the computer controlled opponent, and the wind model. These options are accessed from the "Options" menu selection from the main menu screen.

Course Layout

The course layout dialogue box lets you set the type of course, the length of the course legs, and the amount of prestart time before the start of the race.

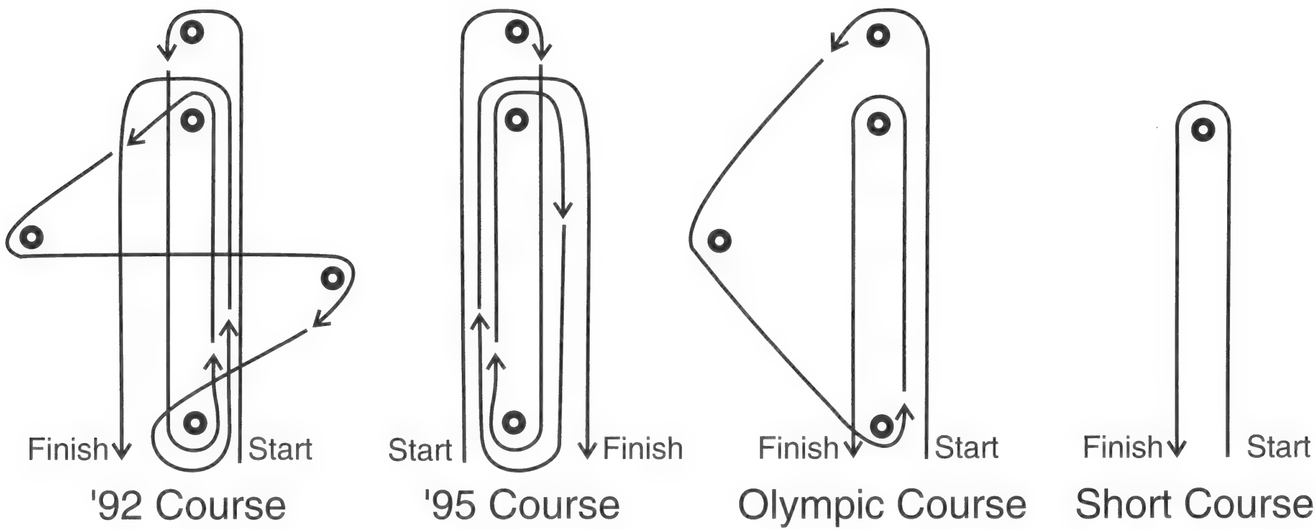


There are four courses featured in *Sail 95*. These are the 1992 San Diego America's Cup course, the 1995 San Diego America's Cup course, an Olympic type triangular course, and a short course.

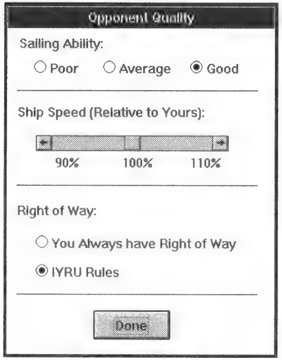
You have the option of selecting less than full length legs for each of these courses. The '92 course, for example, has a total race distance of over 20 nautical miles. Racing this full course, even with strong winds, takes over two hours. *Sail 95* lets you shorten this time considerably by setting a scaling factor for all the course legs. You set this scaling by selecting either "Full Length Legs" for no scaling (for the purist), "Half-Length Legs," "Quarter-Length Legs," or "Tenth-Length Legs" (for the impatient). Setting tenth length legs causes a race to be sailed very rapidly, as you have reduced the leg length to only a few hundred yards. This option makes for a very challenging, albeit quick race. (Imagine sailing a seventy-five foot long yacht around a course no more than 600 yards on a side, and you'll realize that this option is fairly sporting.) Selecting "Quick Race" from the race menu sets the leg lengths to tenth-length, the course type to "Short," and the pretsart to "None."

The prestart period for a race can be set to either none, five minutes, or ten minutes. Selecting none will start the two yachts below the line on split tacks a few seconds before the start. For maximum realism, you'll want to set the prestart period to "Ten Minutes." Bear in mind that races are often won or lost during the prestart.

The diagram shows the layout for the four types of course:



Opponent Quality



The opponent quality dialogue box lets you set your computer controlled opponents sailing ability, his boat's performance, and whether right-of-way rules are in effect.

The "Sailing Ability" section only affects the artificial intelligence employed by the computer for the opponent's boat. It does not affect the artificial intelligence employed by the computer when it is controlling your yacht. With "Poor" selected, your opponent will make errors in how he trims his sails. With "Poor" or "Average" selected, your opponent will have a heavy hand on the rudder, and tend to overcorrect with the rudder when he turns. These are subtle errors that you may make as well: if you want to weight the race heavily in your favor, you should give your opponent a slower boat.

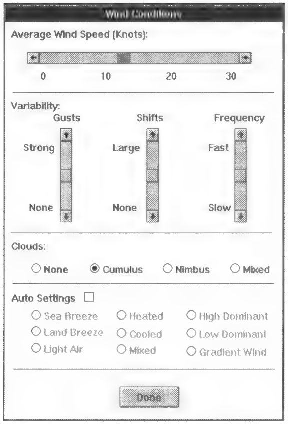
The "Ship Speed" slider lets you adjust your opponent's boat performance relative to yours. You can speed up or slow down his yacht by up to 10%. Setting the slider to a value less than 100% will make your opponent slower than you. When the slider is centered at 100%, the two yachts will have identical performance, much as two one-design boats would have. Any victories or defeats are then entirely the result of superior sailing ability by the victor. A 10% difference in boat speed is extreme: setting the slider to this setting at either end will cause well over a knot of difference in speed between the two yachts in the same wind. In the creation of actual IACC yachts, millions of dollars are spent on design for increases in boatspeed of less than one percent.

You can also set whether or not to use IYRU right-of-way rules in this box. If you choose "You always have Right of Way," you will have a tremendously unfair advantage over your opponent. When set to "IYRU Rules" the right-of-way of one boat over

another is determined in accordance with the rules of the International Yacht Racing Union. See the chapter entitled *Tactics and Strategy* for a full description of these rules as implemented in *Sail 95*.

Wind Conditions

Many variables controlling the *Sail 95* wind model can be set from the Wind Conditions dialogue box. There are two modes of operation of this box: manual control of various settings using the slider bars, and automatic generation of specific types of conditions using the check boxes. Checking or unchecking the box labeled “Auto Settings” switches between these modes.



When “Auto Settings” is unchecked, you can set up the wind conditions using the four slider bars. The settings of these bars do not directly set all the variables of the *Sail 95* wind model — there are over twenty such variables — but they do influence the generation of these variables. Many of the actual variables are set randomly within certain ranges as defined by the sliders. Setting the sliders to the same position on separate occasions will therefore **not** generate an identical wind model twice. If you wish to recreate an identical wind model to use during more than one race, you must save the race before starting it using the file menu.

The topmost slider sets the average wind speed experienced on the course. Setting extremely high values here will not cause your boat to sail much faster than moderate settings would. IACC yachts are currently designed to be sailed under typical San Diego wind conditions, and sailing them under twenty five knots of wind requires reefing

that can actually result in slower speeds than when sailing unreefed in less wind. Setting low settings for the wind speed may seem a bit boring to some, but many races are sailed under conditions of little or no wind. The sailing model used in *Sail 95* is accurate over the entire range of wind speeds, so feel free to set this slider however you like.

The three vertical sliders control how the wind varies over the course. The sliders labeled “Gusts” and “Shifts” work together to determine both the amount of variation in the wind and whether that variation is seen as mainly changes in wind speed or shifts in wind direction. Additionally, the difference in the two settings also affects the regularity of the shifts or gusts. Setting the two sliders to similar values will create less predictable shifts and gusts than setting the two differently. The third vertical slider, labeled “Frequency,” controls the period of any regular oscillations: setting this slider to “Fast” creates oscillations with less time between them than setting this slider to “Slow.” See the chapter entitled *The Wind* for a description of the mechanisms behind wind shifts and gusts.

The types of clouds encountered while sailing can also be set manually. The choices here are “None,” “Cumulus,” “Nimbus,” or “Mixed.” These clouds will appear from time to time while sailing a race. The “Cumulus” setting will create small localized puffy white clouds while the “nimbus” setting creates small rain clouds. The type of cloud determines what effect it will have on the wind. See the chapter about wind for a description of these effects.

Auto Settings

Checking the box labeled "Auto Settings" will dim the manual sliders and allow you to set the wind conditions from a combination of radio buttons. There are nine such buttons, arranged in three columns of three. You set one button from each column, for a total of three buttons. There are therefore 3x3x3 or 27 possible combinations of these buttons.

The first column sets the type of coastal conditions you are sailing under. The second column determines whether the air over the water is being heated or cooled by the water. The third column sets the predominant weather conditions. For a description of these factors see the chapter *The Wind*.

Now let's look at the controls within the simulator itself.

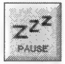
Simulator Push-Buttons

The simulator contains two columns of five push buttons that control various play options from within the simulator.

Sound and Music

The top two left hand column buttons set the sound or music on or off. You cannot adjust the volume of the sound or music from within the simulator. If you wish to do this, you'll need to use the software controls that are provided with your sound card. All of these cards provide some sort of mixer control that is configurable within Windows. Use this to set the relative volume of sound and music to your liking. You can, of course, set the overall sound and music volume directly on your external amplifier or speakers.

Pause



This button lets you pause the simulator. You can do this if you need a break, or to examine your tactical situation more leisurely before deciding upon an action. To resume the race, click on the depressed button.

Menu

This button will return you from the simulator screen to the main menu screen. All action within the race will be suspended until you return to the race using the "Resume Race" menu option. Note that when you resume a race in this manner, you will loose your previous "Wind History" graph as well as the red and yellow trails on the overhead view. This is normal and is due to memory considerations.

Exiting

To exit *Sail 95*, you need to use the menu button to first return to the main menu. From the main menu select "Exit" from the "File" menu. If you terminate the program improperly from the simulator screen (by using Ctrl+Alt+Del for example), you should restart Windows before doing anything else.

Spinnaker

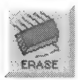
This button will raise and lower the spinnaker on your boat. Note that when the spinnaker is raised, you **cannot** sail higher to the wind than about 60^{o}. Your rudder will simply not turn your boat into the wind when the spinnaker is up. If you're trying to come about and you can't, make sure you don't have your spinnaker up.

Automatic Controls

The three buttons on the top of the right hand side column allow you to set automatic control of your yacht. The topmost button, labeled "Tack," engages automatic control of your yacht's tacking and tactical maneuvering as well as automatic collision avoid-

ance. The second button, labeled "Course," engages automatic steering to the best upwind or downwind heading for the current wind conditions. The third button, labeled "Sheeting," engages automatic control of your sail trim. Depressing the "Tack" button will also cause the "Course" button to depress: you can't very well have automatic control of tacking and maneuvering without also having automatic control of the steering. Note that sailing with the "Course" button engaged without the "Tack" button engaged will only sail the yacht to a proper upwind or downwind course: no collision avoidance or tactical maneuvering will occur.

Erase



The button labeled "Erase" will clear the red and yellow trails of the two yachts on the overhead tactical view. These trails can become quite cluttered after several legs of a full course. There will be a noticeable pause after this button is depressed while the simulator loads a clean view of the course. This is normal.

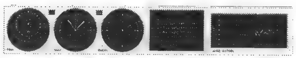
Compass View

This button lets you select one of four views for the remote view. The button is divided into four parts corresponding to the four cardinal compass directions. Pressing on a direction will shift the view to face in the direction indicated. This button will enable you to maintain a view of your opponent even if he is behind or to the side of you. Be careful not to become disoriented when using one of the views other than the one looking north. The overhead tactical view is always oriented with north at the top of the screen, so the remote view only coincides with the tactical overhead view when it is looking north as well.

Yacht Controls

There are three methods of manual control of your *Sail 95* yacht. These include mouse control within the cockpit view, mouse control using the rudder bar, and joystick control. These controls are all described in the "Quick Start" chapter.

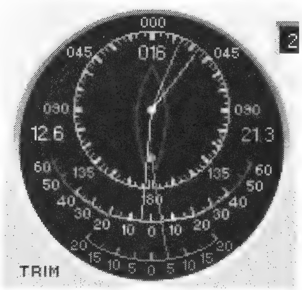
Instrumentation



Sail 95 features a sophisticated instrument panel enabling you to assess your yacht's performance and your tactical situation. The instrument panel contains three circular instruments, two digital displays, an onboard computer screen, and a graphic display of wind velocity history.

Trim Instrument

The leftmost circular instrument is the trim instrument. This instrument provides information on your current sail and rudder position as well as relative and absolute wind information.



At the center of this dial, shown in red, is your yacht. The green needle extending to the bottom of the dial shows your current rudder position. This information is repeated at the top of the screen in the rudder bar. The red needle shows your current sail sheeting. Note that this display shows two colors of numbers around the dial. The yellow numbers indicate sheeting angles that can be selected using your genoa; the magenta numbers show sheeting angles that can be selected using your spinnaker. Note that from 20° to 40° these colors overlap indicating you can use either foresail. This sheeting information is also repeated at the top of the screen.

The light blue circular dial around the central red boat indicates the relative bearing of both the true and the apparent wind. The white needle shows the true wind's bearing and the light blue needle shows that of the relative wind.

The numeric readout in white at the left hand side of the dial indicates the true wind speed in knots. The light blue readout at the right side of the dial shows the apparent wind speed in knots. The yellow numbers inside the top center of the dial indicate the current angle of your sail to the relative wind (α). Ideally, you want to keep this number around 20^{o}. See the chapter on sailing theory for a discussion of true versus relative wind and angles of attack.

Nav Instrument

The middle of the three circular instruments shows navigation information about your boat. The light blue dial around the outside of this instrument gives your heading and the compass bearing to both your opponent and the next mark.

The green needle shows your current compass heading. The yellow needle shows the compass bearing to your opponent and the magenta needle gives the compass bearing to the next mark. If you are in the prestart period or on the final leg of a race, this needle gives the bearing to the closest side of the start or finish line. The white needle gives the compass bearing of the true wind. Note that these are all absolute compass bearings while the wind bearings shown on the trim instrument are relative bearings.

At the bottom of this dial, shown in green, is a numeric readout of your current boat-speed in knots. At the left side of the instrument, shown in magenta, is a numeric

readout of the distance in feet to the nearest mark (or, if in the prestart period or on the finish leg, the closest side of the line.) The right side of the instrument shows the distance, again in feet, to your opponent. At the top of the instrument the true wind speed is shown in white. The true wind speed is repeated in the trim instrument.

Prior to the start of the race, your north-south distance to the starting line in feet is shown in green just above the center of this display, below the true wind speed.

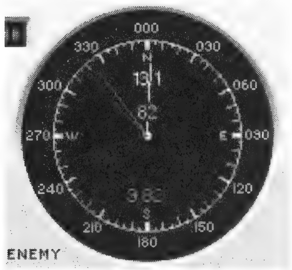
Two gray "rabbit ears" are shown to either side of the white true wind direction needle. These are an aid for achieving a proper course when sailing upwind. If you sail your yacht such that the green heading needle is within one of these gray markers, you will be close to the course that will maximize your upwind VMG (velocity made good.) These markers are also a good indicator of when you should tack to stay on the preferred tack. The gray marker that is closer to the top of the instrument indicates the heading for the preferred tack. See the chapter *Sailing Theory* for a discussion of VMG and preferred tacks.

Enemy Instrument

The rightmost circular instrument gives valuable information about your opponent's situation. Some of this information would not be readily available during an actual race, but is provided in *Sail 95* to aid the player.

This display is very similar to the "Nav" display showing information about your boat. The yellow dial around the outside of this instrument shows compass bearings for your opponent's heading, his bearing to the next mark, and his bearing to your boat.

The green needle indicates your opponents heading. The magenta needle shows the bearing from your opponent to the next mark. The red needle shows the bearing from your opponent to your boat. Note that this is a reciprocal bearing to your bearing to him shown on the "Nav" instrument.



Your opponent's current boatspeed is shown at the bottom of the instrument in green. The left side of the instrument shows, in magenta, the distance in feet from your opponent to the next mark. The right side of the instrument shows, in red, the distance from your opponent to your boat. Note that this information is the same as the distance from your boat to your opponent's shown in the "Nav" instrument.

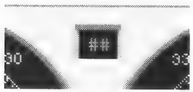
Above the center of this instrument is a numeric readout of how far ahead or behind you your opponent is. If this readout is yellow, your opponent is ahead of you by the number of feet indicated. If this display is red, you are ahead of him by the number of feet indicated. Note that this is not the same as the distance between the two boats. The two boats could be on split tacks and still be quite even with one another despite being a great distance apart. This is also not the difference between the two boats' distances to the next mark. One boat could be quite close to an upwind mark, but be directly downwind from it, while the other boat, though further away, was in a position to sail directly to the mark.

Heel Indicator

Between the "Trim" and "Nav" instrument is a small digital readout window. This displays your current heel angle in degrees. When your heel reaches twenty five degrees,

Sail 95 will automatically reef your sails to maintain a maximum heel of twenty five degrees. This is not shown in the graphic displays. This instrument is the only indication that reefing is occurring.

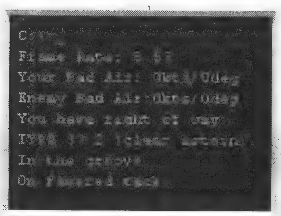
Collision Indicator



Located between the "Nav" and "Enemy" instruments is a second digital display that shows who has right-of-way and potential collisions between the two yachts. If this display is green, your yacht has right-of-way. If it is yellow, your opponent has right-of-way. If the simulator detects a potential collision within the next thirty seconds or so, this display will flash indicating the number of seconds to the collision. Even if you have right-of-way, you should still attempt to avoid a collision, as serious damage to your yacht can result in the race ending prematurely. The race committee could also find that you failed to take avoiding action when possible and you will forfeit the race.

Ship Computer

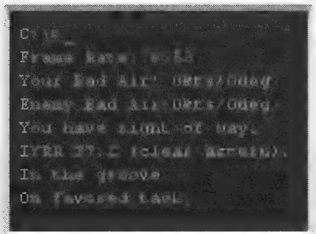
Your high performance yacht is also equipped with an onboard MSDOS computer which provides valuable additional information about the race.



Reading from top to bottom, the following information is provided:

- The average frame rate at which the simulator is operating. This is a dependent upon your hardware. *Sail 95* will automatically adjust all its speeds to maintain real-world times and speeds.
- The change in the wind that **you** are experiencing due to your opponent blocking some of your wind. Both the change in the wind's heading and the

change in wind speed are given. Use this information to see how badly you are being covered by your opponent.

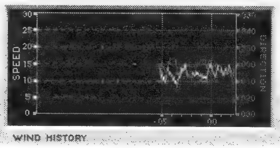


- The change in the wind that **your opponent** is experiencing due to your blocking his wind. Use this information to see how effectively you are covering him.
- Who has the right-of-way.
- What IYRU rule is determining the right-of-way. If either ship has a penalty due because of a collision, this line will indicate that a penalty turn is due by showing how many degrees of turn are remaining. All penalty turns in *Sail 95* are right (clockwise) turns. If your ship is under automatic tacking control, any penalty turns will be taken automatically when you are well clear of any marks. If the penalty turn indicator is flashing yellow, this indicates that **you** need to take the penalty turn; if it is green, your opponent needs to take the turn.
- Advice on your sail trim describing the corrective action you need to take if this is less than optimal. Note that this line will sometimes prescribe corrective action even when your ship is using automatic sheeting. This is because the automatic sheeting is computed based upon target boat speeds and headings to the true wind. The advice on this line is based solely upon your relative wind. If your boat is accelerating or decelerating, your relative wind will differ from what it will be when you are up to your target speed.
- Whether or not you are on the favored tack. (Upwind legs only.) Use this as a guide if you become confused as to which tack you should try to be on. This

information is only based on true wind heading, so don't use it to know when to tack onto a layline or tack back towards the center of the course.

Wind History

On the far right of the instrument panel is a two color graph showing you a history of the true wind behavior over the last twenty minutes. This information is the wind **your yacht** has experienced. The wind speed history is shown in white, and the wind heading is shown in green. (If you mentally rotate this graph 90^{o} counter-clockwise, the scale for the wind heading will correspond to the wind heading as your yacht has experienced it.)



Wind changes in *Sail 95* move just as do such changes in the real world. When you experience a local gust or shift, that gust or shift is moving across the course. Note that such a change does not necessarily move at the same speed and direction as the wind itself, especially in the case of a veer. You cannot actually tell the direction a wind change is moving in, but you can attempt to infer it from the history graph. (When actually out on the water, you can **sometimes** judge this information by looking at disturbances on the surface of the water and seeing how they move.)

The most important use of the wind history graph is to try to determine what regular periodic wind shifts are occurring. If you determine that an oscillatory pattern is repeating, you can use this information to try to stay in phase with the wind shifts by planning your tacks to coincide with the shifts. Remember that any clouds you pass near will affect the wind that you experience, so you will need to take their influence into account when determining any oscillating patterns. Also remember that your

yacht's position on the course affects how you perceive any gusts or shifts since these are moving with time across the course. You may be beginning to realize why some people regard competitive yacht racing as one of the most intellectually challenging of all sports.

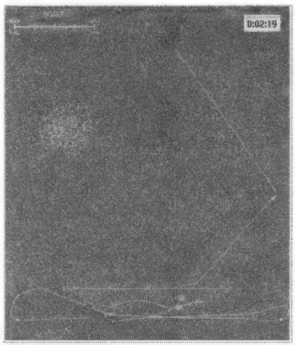
Note that if you exit the simulator to the main menu screen and then return to a race, that the wind history will not retain any previous information. This is normal and due to memory limitations within the simulator.

The Big Picture

The most important skill a good pilot possesses is the ability to keep track of many different things simultaneously. Those who fly fighter aircraft call this "the big picture" and maintaining an awareness of it "SA" or situational awareness. A common fault of novice pilots is to focus too intently upon an individual problem and loose track of their overall situation. They are then said to have left their "SA in the map case." This is especially a problem when faced with an emergency or combat situation and is the prime reason why the USAF relies so heavily on peacetime combat training (Red Flag) and emergency procedure simulator training. Even in wartime more jets are lost due to collision with the ground because of "target fixation," preoccupation with an in-flight emergency, or general task saturation than due to being shot down by enemy action.

What does this have to do with yacht racing? The same problems of maintaining proper overall situational awareness exist when sailing. It is all too easy to become preoccupied with one thing or another and then neglect something crucial like where you are on

the course. The player of *Sail 95* is further hindered by the fact the simulator is, after all, only PC software. He is not able to receive sensory input from all five senses through 360° as someone actually on the water can. Fortunately, *Sail 95* was designed to minimize the task load on the player as much as possible so he can maintain the "big picture." This is why the player is given the option of computer assisted yacht control, why sail trim and sail selection have been drastically simplified, why there are no water currents to worry about, why the courses are always situated with north at the top, and why the pause button exists. If you feel you are "getting behind" your boat or like your yacht is sailing you instead of *vice versa*, don't hesitate to use the pause button. After all, *Sail 95* was designed to be fun.



The large view on the right side of the screen is also designed to help you maintain a good overall perspective on the race. The entire course is always shown in this view with north at the top of the screen. By always being able to see the whole course, it is easier to maintain proper situational awareness of the race. This view is also a great aid to navigation. You need not worry about remembering the specific course layouts because this view will always indicate to you where the next mark is and on what side of it you should be passing. (If the mark is blinking red, pass it to the right; if it is blinking green, pass it to the left.)

Do not, however, rely on the overhead view for collision avoidance. Except when sailing with one-tenth length legs set, the red and yellow yachts shown on the overhead view are not to scale. They are shown larger than scale so that you can see when a boat is turning. This means that the two boats on the overhead screen are actually further

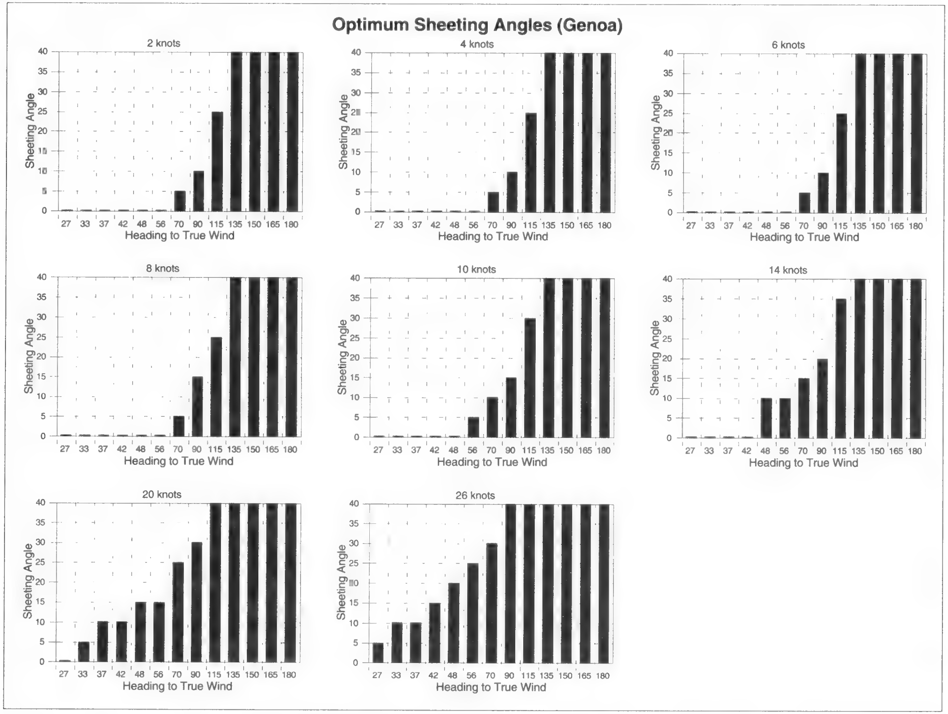
apart from each other than they appear (except when one-tenth length legs are set). The remote view in the upper left portion of the screen is a much better indicator of whether the two yachts are going to collide. If it looks like a collision is going to occur in this view or in the cockpit view, you'd better start turning!

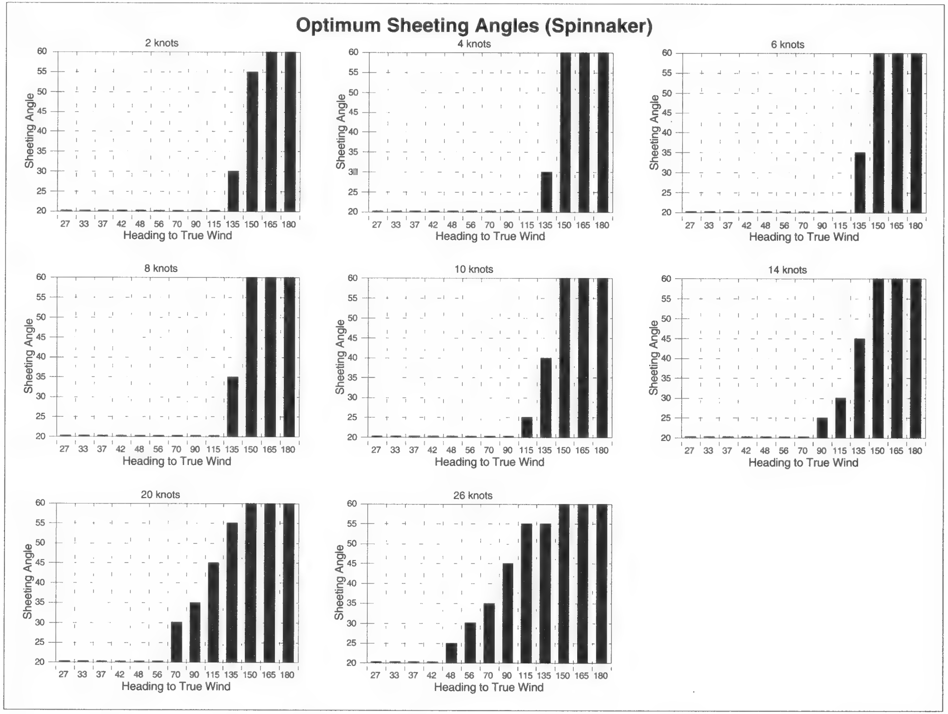
Happy sailing!

Performance Data

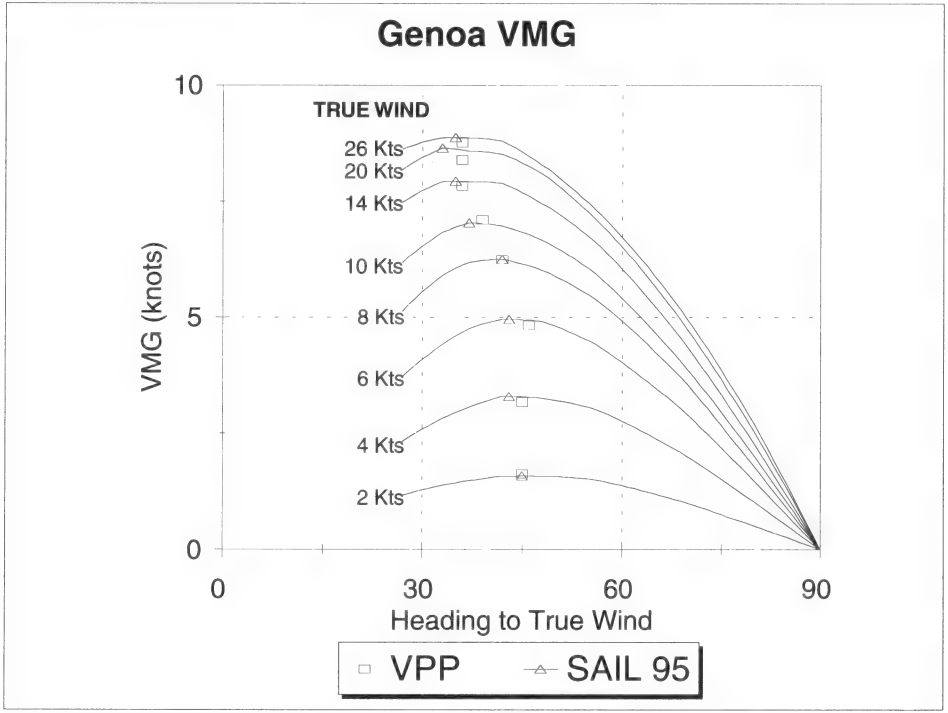
The data sets that follow all show measured Sail 95 performance. Actual velocity prediction program (VPP) data for a generic IACC yacht are included for comparison purposes. (Specific data for individual yachts are still closely guarded.) Use this information to help you achieve the maximum performance from your Sail 95 IACC yacht.

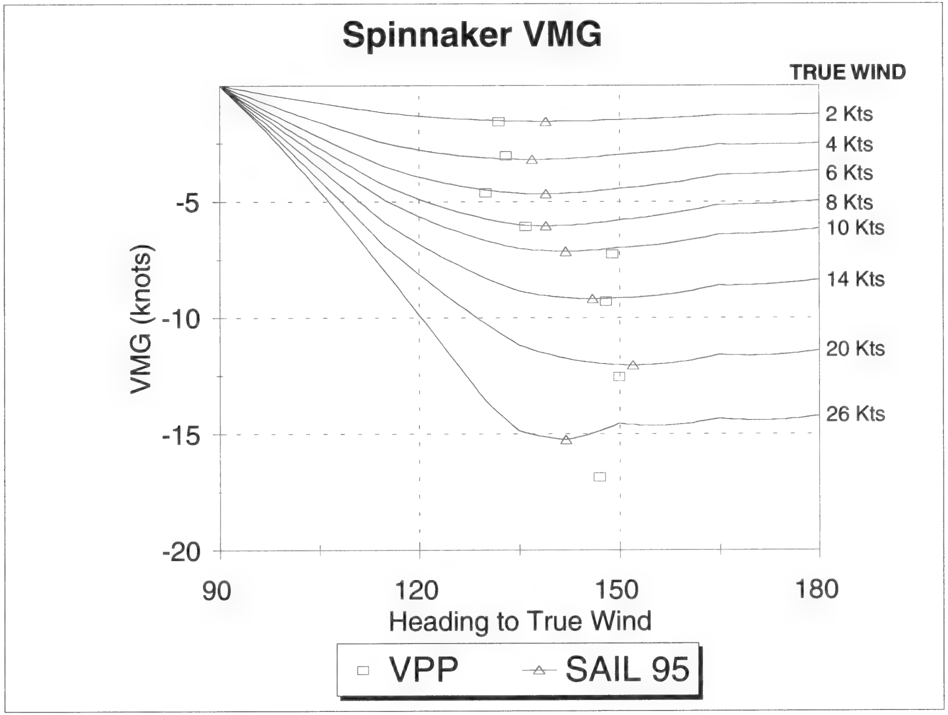
Sheeting Angles



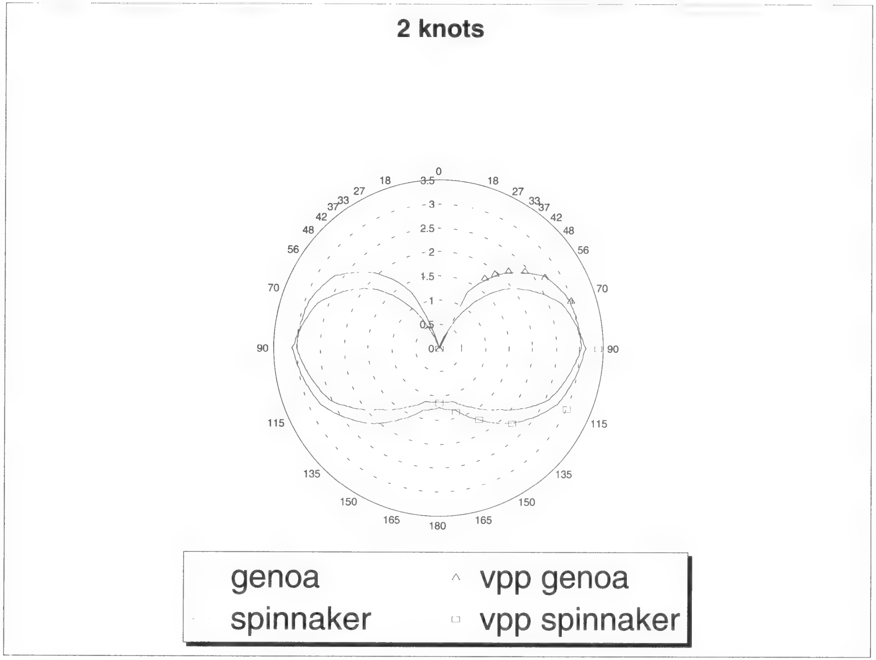

Optimum Sheeting Angles (Spinnaker)
2 knots
4 knots
6 knots
8 knots
10 knots
14 knots
20 knots
26 knots
Sheeting Angle
Heading to True Wind
27 33 37 42 48 56 70 90 115 135 150 165 180
20 25 30 35 40 45 50 55 60

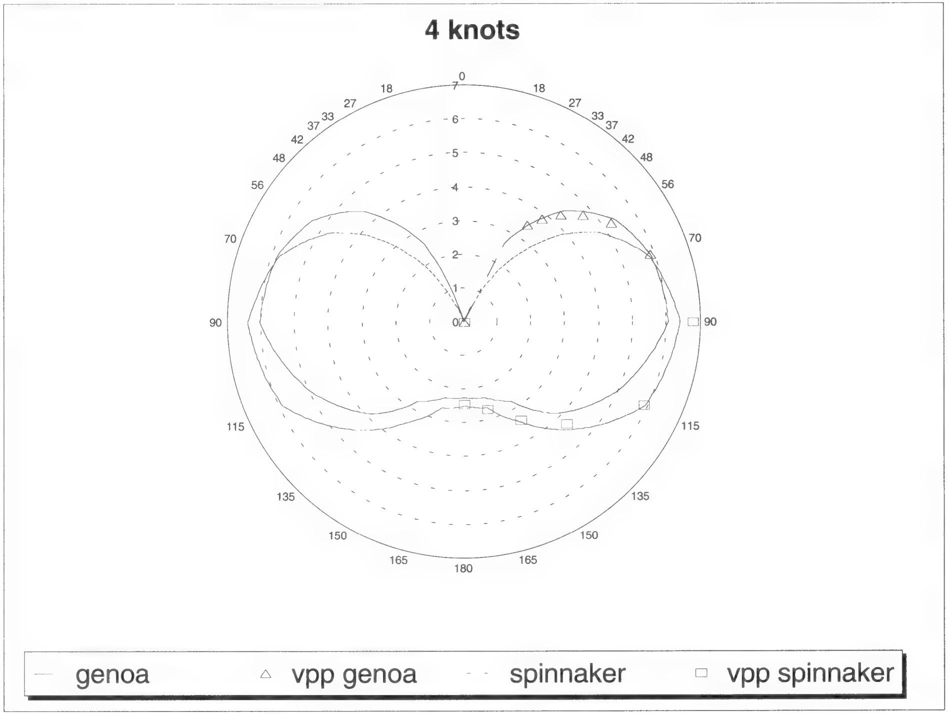
VMG

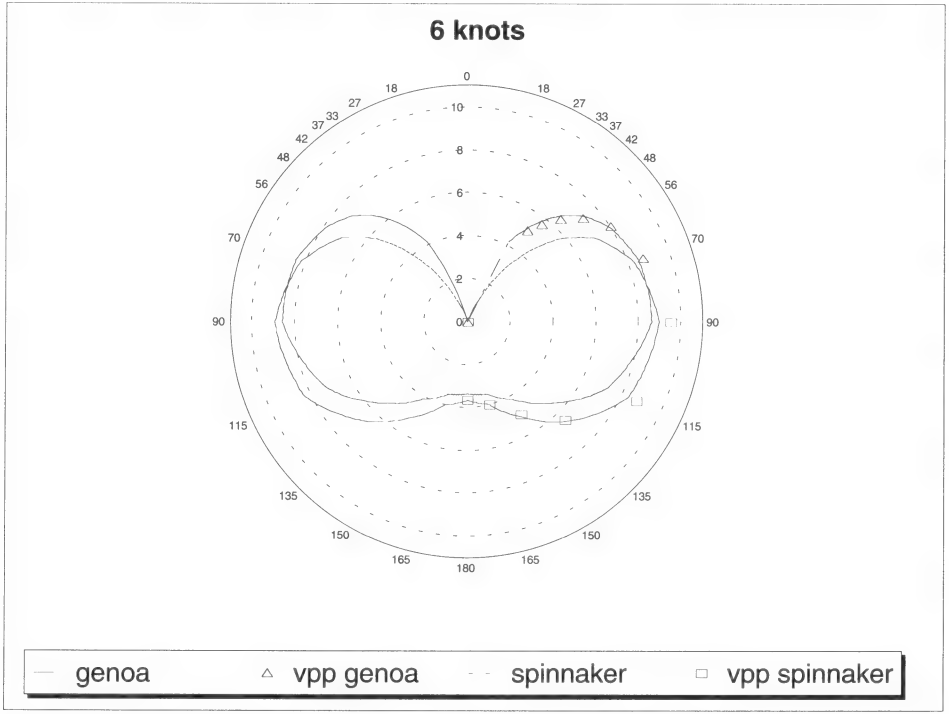

Genoa VMG
TRUE WIND
26 Kts
20 Kts
14 Kts
10 Kts
8 Kts
6 Kts
4 Kts
2 Kts
VMG (knots)
10
5
0
0
30
60
90
Heading to True Wind
VPP
SAIL 95

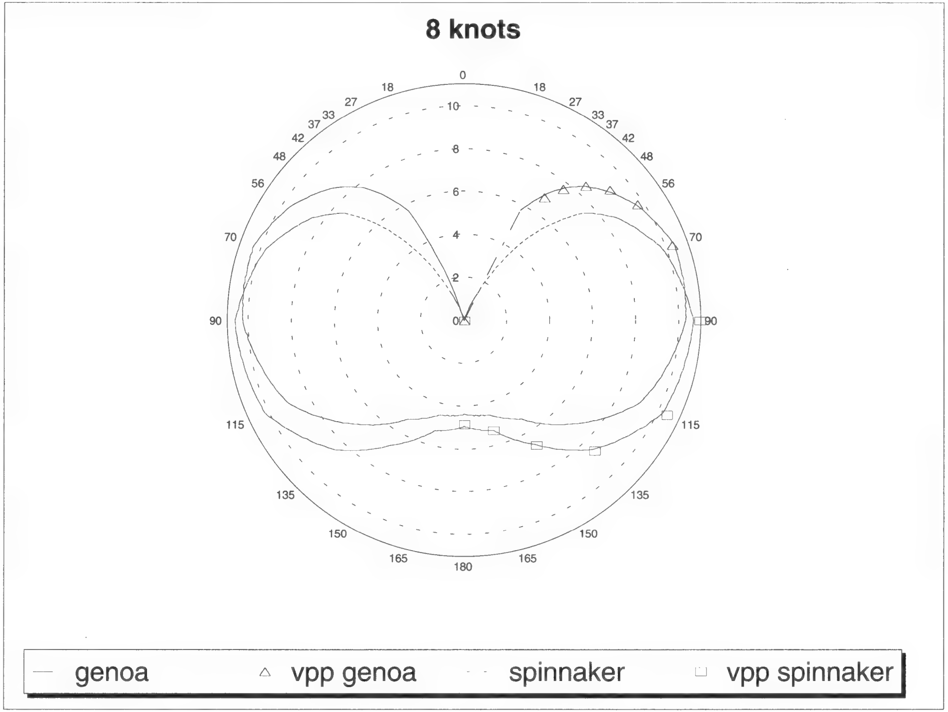

Spinnaker VMG
TRUE WIND
2 Kts
4 Kts
6 Kts
8 Kts
10 Kts
14 Kts
20 Kts
26 Kts
VMG (knots)
-5
-10
-15
-20
90
120
150
180
Heading to True Wind
VPP
SAIL 95

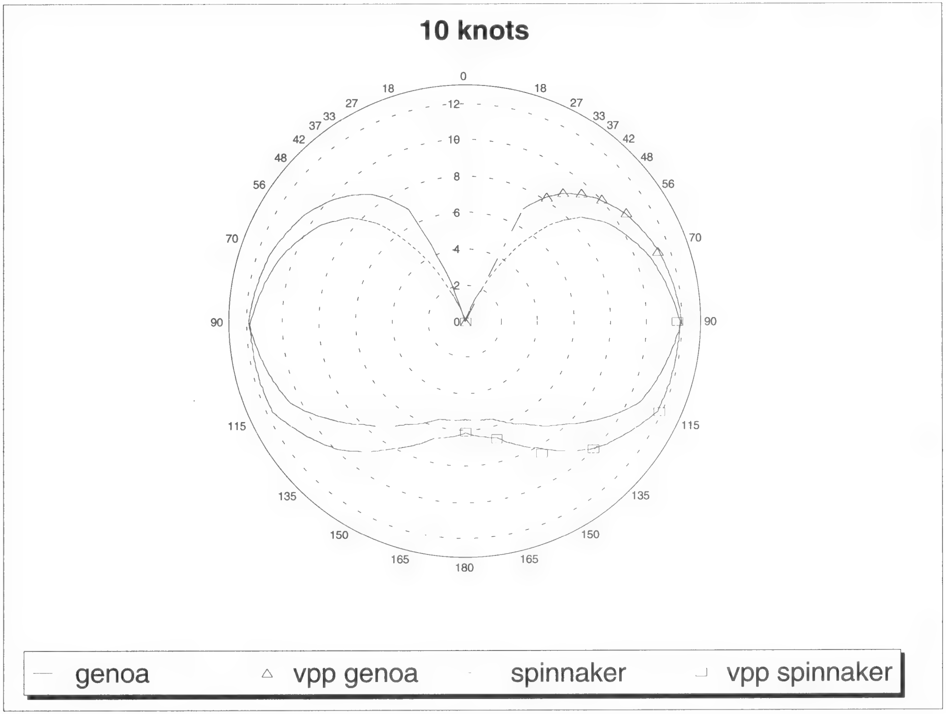
Polar Speed Plots

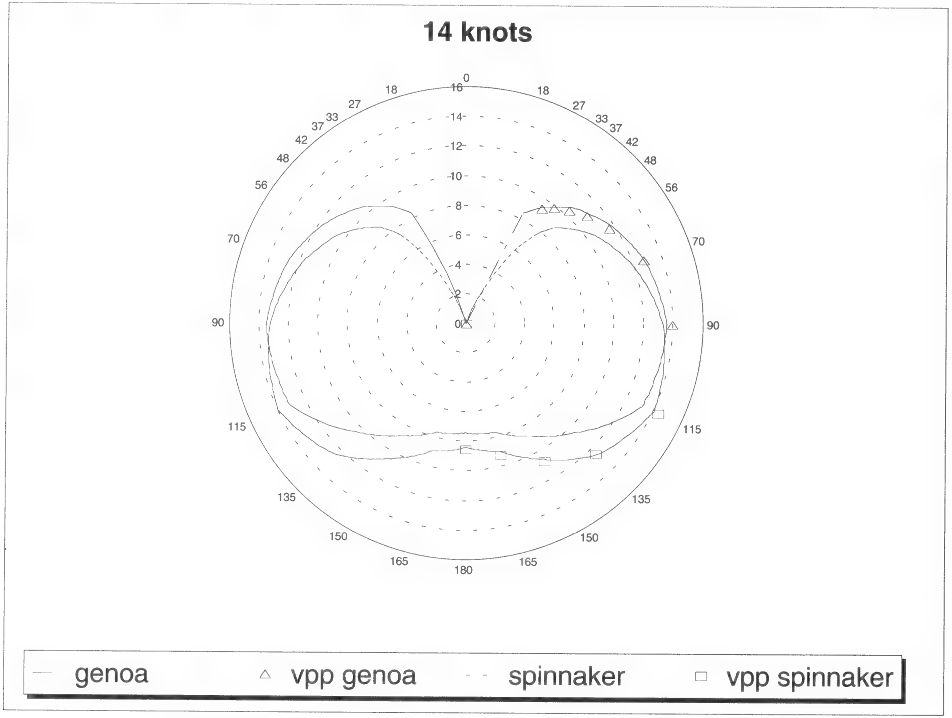


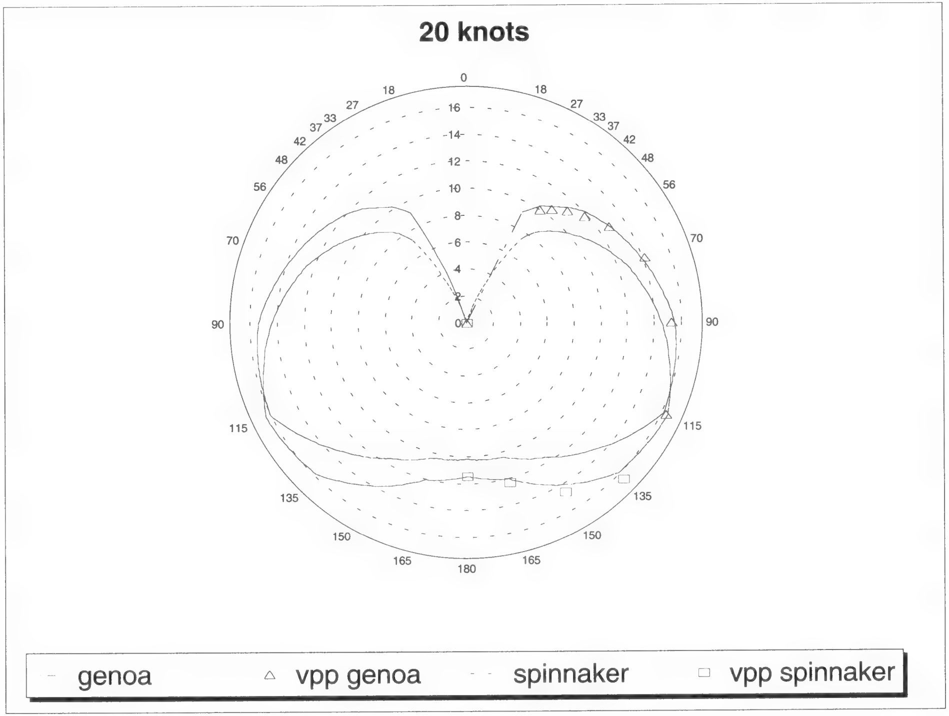

4 knots
0
18
27
33
37
42
48
56
70
90
115
135
150
165
180
7
6
5
4
3
2
1
0
genoa
vpp genoa
spinnaker
vpp spinnaker

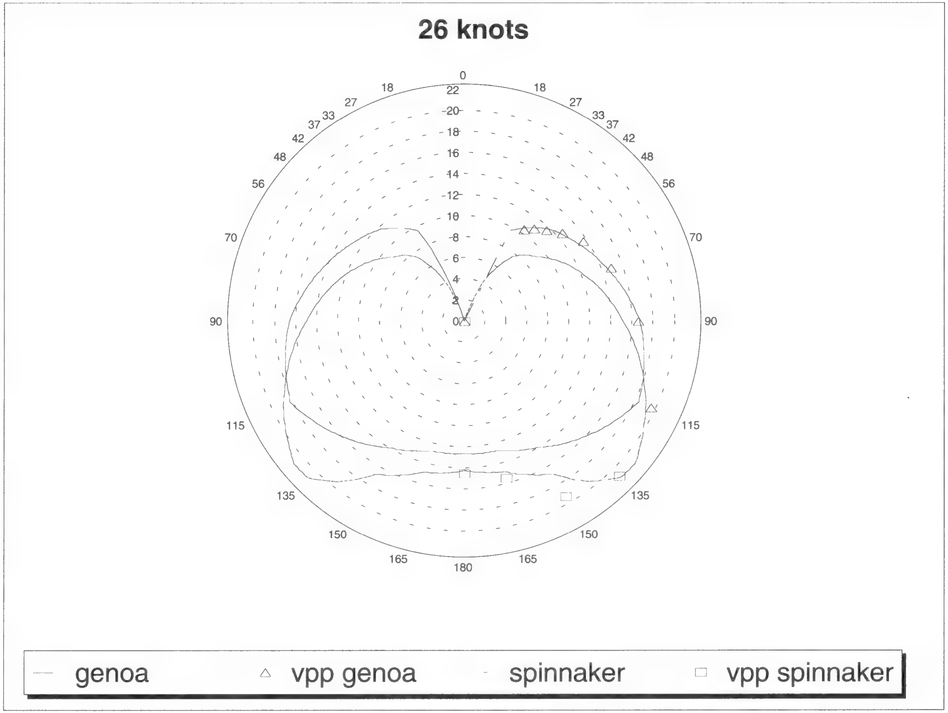

6 knots
0
18
27
33
37
42
48
56
70
90
115
135
150
165
180
10
8
6
4
2
0
genoa
vpp genoa
spinnaker
vpp spinnaker


8 knots
0
18
27
33
37
42
48
56
70
90
115
135
150
165
180
10
8
6
4
2
0
genoa
vpp genoa
spinnaker
vpp spinnaker


10 knots
0
18
27
33
37
42
48
56
70
90
115
135
150
165
180
12
10
8
6
4
2
0
genoa
vpp genoa
spinnaker
vpp spinnaker


14 knots
0
16
14
12
10
8
6
4
2
0
18
27
33
37
42
48
56
70
90
115
135
150
165
180
genoa
vpp genoa
spinnaker
vpp spinnaker


20 knots
0
18
27
33
37
42
48
56
70
90
115
135
150
165
180
16
14
12
10
8
6
4
2
0
genoa
vpp genoa
spinnaker
vpp spinnaker


26 knots
0
18
27
33
37
42
48
56
70
90
115
135
150
165
180
22
20
18
16
14
12
10
8
6
4
2
0
genoa
vpp genoa
spinnaker
vpp spinnaker

International America's Cup Class

The International America's Cup Class must meet the following rule:

$$\frac{Length + 1.25 \times \sqrt{Sail\ Area} - 9.8\, meters \cdot metric\ tons^{-\frac{1}{3}} \times \sqrt[3]{Displacement}}{0.388} \leq 42\, meters$$

where *Length* is in meters, *Sail Area* is in square meters, and *Displacement* is in metric tons.

The IACC yachts modeled in *Sail 95* have the following dimensions:

Rated Length:	76 feet
Rated Beam:	14 feet
Sail Area:	3100 square feet
Displacement:	53,000 pounds

IACC yachts carry a crew of 16 including: 6 grinders, 7 sail trimmers and handlers, a helmsman, a tactician, and a navigator.

Suggested Reading

Bibliography

There are literally thousands of books available on sailing. Any major bookstore generally has an entire section devoted to the subject. The following list represents a selection of titles that I have found to be especially informative and worthwhile.

Sail Like A Champion

by Dennis Conner and Michael Levitt, published by St. Martin's Press: New York, 1992. 392 pp.

This is a good general introduction to sailboat racing. It is written in an informal, easy to read style. Mr. Conner uses his years of America's Cup racing experiences to reference theory to practice. Mr. Conner will be competing in the defender trials for the America's Cup this spring.

Around The Buoys — A Manual of Sailboat Racing Tactics and Strategies

by Michael Huck, Jr., published by International Marine: Camden, Maine, 1994. 232 pp.

This is a more detailed book about racing. The author presents his information clearly and concisely. A wealth of illustrations aid in explaining all aspects of racing theory.

High Performance Sailing

by Frank Bethwaite, published by TAB Books, McGraw-Hill: Great Britain, 1993. 413 pp.

This is a fascinating work that explores a number of subjects relating to high speed sailing. Mr. Bethwaite's background is in meteorology as well as olympic sailing, and this book contains the best discussion of wind and weather anywhere.

Sail Power — The Complete Guide to Sails and Sail Handling

by Wallace Ross, published by Alfred A. Knopf: New York, 1992. 514 pp.

Sail 95 does not focus on the art of sail handling except in the crudest sense of mainsheet trim. If you race this is a subject you must be familiar with. This book, written by a sail maker, covers all aspects of sail use, manufacture, selection, and trim. If you don't actually sail it will seem very dry.

Aero-Hydrodynamics of Sailing

by C. A. Marchaj, published by International Marine: Camden, Maine, 1991. 743 pp.

This opus, usually referred to simply as "Marchaj," is the definitive work on sailing theory. The book is quite detailed, and requires a good working knowledge of high school trigonometry, elementary physics, and basic vector arithmetic. Surprisingly, no knowledge of the Calculus is required. Even so, this book can be hard going at times. If you have any interest in this subject, however, this book is magnificent. *Sail 95's* dynamic sailing model is based in large part on the theoretical information contained within this work.

Acknowledgments

My thanks to the POV-RAY team and Bill Pulver in particular for POV-RAY. POV-RAY is an extremely powerful raytracing program available as freeware from any on-line service. All the images in *Sail 95* were rendered using this software.

My thanks to Peter T. Schween of Design Systems for sharing his knowledge of the IACC class with me and providing IACC performance data.

Vivid Simulations

90 High Street ☯ Clinton, CT 06413